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President's Page

*Prepared by General Secretary A. Nelson Sayre upon invitation of the President,
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Primitive man was so fully occupied with procuring enough food and clothing for bare subsistence that he had little time to ponder the significance of the natural phenomena which he observed. Nevertheless he accumulated a vast store of information of practical value. Civilization began, we are told, when technology had advanced sufficiently so that part of the population was able to provide sufficient food for the whole and the remaining part of the population was able to devote itself to the development of arts and crafts and eventually to philosophy and science. This change appears to have coincided with the development of irrigation and, at least partly, as a result of it. The origin of the water that feeds wells and springs and rivers was doubtless a matter for speculation from very early civilization, but the Greeks were the first to formulate definite, although incorrect, hypotheses about it. Thales, Aristotle, and Plato concluded that rainfall was insufficient in quantity to supply the water of springs and rivers and therefore the springs must be fed by sea water which was forced into subterranean caverns where it was raised and purified beneath the hills and issued forth in springs.

The old Greek hypotheses were accepted by most philosophers with the notable exceptions of Vitruvius, Leonardo da Vinci, and Bernard Palissy until near the end of the seventeenth century. At that time, Perrault estimated the discharge of the Seine and measured the precipitation on the watershed of that river. He showed that the precipitation was about six times the quantity of water discharged by the river. A little later Mariotté made measurements of precipitation and runoff in the Seine valley over a three-year period and reached a similar conclusion. Halley, the English astronomer, demonstrated that the evaporation from the Mediterranean was ample to supply the water of the rivers flowing into that sea.

The moral of the above paragraphs on the birth of scientific hydrology is known to every scientist—observation and measurement are the foundation stones of science. Theory must be tested by observations which can be repeated by others. On the other hand, observations, however carefully made, achieve scientific significance only when they are evaluated and interpreted. By their measurements, although very crude, Perrault, Mariotté, and Halley pointed the way to a correct understanding of the hydrologic cycle, and founded the science of hydrology. Since their time, workers in many different branches of geoscience have greatly improved the methods, techniques, and interpretations of hydrology. Only within the last 40 years has hydrology been recognized as a distinct field of Earth science.

Like other fields of science hydrology has developed specialized branches. Although these branches have in common the study of the circulation of free water from the time it reaches the land surface until it is evaporated or returned to the ocean, their objectives are quite different and the skills and techniques required are generally quite distinct. The Branches now recognized by the Section of Hydrology of AGU are: (1) Surface Water; (2) Ground Water; (3) Evaporation and Transpiration; (4) Snow; (5) Glaciers; (6) Precipitation; and (7) Erosion and Sedimentation. The workers in these branches include engineers, geologists, agronomists, foresters, meteorologists, physicists, chemists, soil scientists, etc. All are concerned with making rigorous studies of all the base data to determine the principles and laws involved in the occurrence, movement, and work of waters in the hydrologic cycle. Perhaps the greatest difference between them stems from the properties of water itself. It has the solvent, evaporative, and other properties which make it essential to the life processes of plants and animals

and to adapt it to many domestic and industrial uses. To the agronomist and the forester it should fall at the right time and in the right amount to promote optimum plant growth. They tend to consider any excess water which sinks to the ground-water reservoir or runs off overland as being 'lost.' To the engineer water that is evaporated or transpired (on the average about 70 per cent of the precipitation in the United States) is not available for man's many uses, and therefore is considered as 'lost.' To the conservationist and the engineer an excess of water causes erosion of fertile lands and sedimentation of surface reservoirs and is therefore harmful. Thus, there is a built-in divisive quality to the science of hydrology. Yet the science serves the needs of all and is, or should be, an integrated rather than a diverse field. AGU has in the past served to bring together these diverse interests. I hope that it will continue to do so.

Most of the branches of geophysics have 'built-in' divisive qualities similar to those in hydrology, and need a cohesive influence to prevent fragmentation and to promote the exchange of information and ideas. Although the branches of geophysics have different objectives and employ distinctive techniques, they have many common interests which can be promoted best by an interdisciplinary organization. For

example, hydrology is intimately related to the other geophysical sciences, particularly to meteorology, oceanography, and geology. There are an increasing number of interdisciplinary researches such as the effect of the recent investigation of the seismic disturbance in Montana on ground-water levels in places as distant as New York and Florida, the effects of reservoirs and glaciers on the isostatic balance, and the role of water as a geologic agent. It is important that the AGU should continue to provide the cohesive influence that will promote these and other interdisciplinary studies.

Particularly during the last half century a vast store of hydrologic information has been accumulated, and theories have been developed and tested. However, even now we are deficient in most of our data programs and in some, ground water, erosion and sedimentation, and evapotranspiration, to name only a few, the deficiency is alarming. We are even more deficient in the interpretation of these data in terms of water management and control. With the explosive increase in population we cannot, as a nation, or as a scientific union, afford to allow the rapid progress that has been made in science, including hydrology, to be retarded. It is the earnest hope of the AGU that, through its publications, it will continue a leading role in stimulating the acceleration of this progress.

A National Oceanographic Program

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AND

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In February of 1957 a group of oceanographers and representatives from various agencies of the Federal Government met at the request of Dr. Bronk, President of the National Academy of Sciences, to discuss the question of whether or not the Academy should make a study of the status of the marine sciences. Present were representatives from the Navy, the Bureau of Commercial Fisheries, the Atomic Energy Commission, small and large oceanographic institutions, and other groups concerned with the marine sciences. They soon discovered that they had in common the knowledge that their day-to-day, month-to-month problems in the development of various programs could not be solved without a considerable increase in the development of marine sciences in the United States.

In its rapidly expanding development of complex weapons systems, the Navy has outstripped the storehouse of fundamental information available concerning its operating environment. Our understanding of processes affecting the harvesting of food from the sea are inadequate in comparison with the extensive development of agriculture. The sudden appearance of radioactivity in man's environment has created many problems for which knowledge of the oceans is required. Thus it was natural that the three main sponsors of the suggestion that the Academy conduct a special study of the needs for a national program in oceanography were the Navy, the Bureau of Commercial Fisheries, and the Atomic Energy Commission*.

* The National Science Foundation later joined this group of sponsors of the Committee on Oceanography.

During the course of the discussions, it became apparent that our rapidly expanding technology was placing tremendous demands on the few scientists who had been devoting their lives to the search for basic information about the seas.

Convinced that the Academy should conduct an extensive study of the nation-wide needs for oceanography, Dr. Bronk appointed Dr. Harrison Brown, Professor of Geochemistry at the California Institute of Technology, as chairman of the new committee. Later, the full membership consisted of: Maurice Ewing, Lamont Geological Observatory, Columbia University; Columbus O'D. Iselin, Woods Hole Oceanographic Institution; Fritz Koczy, Marine Laboratory of the University of Miami; Sumner Pike, formerly Commissioner, U. S. Atomic Energy Commission; Colin Pittendrigh, Department of Biology, Princeton University; Roger Revelle, Scripps Institution of Oceanography; Gordon Riley, Bingham Oceanographic Laboratory, Yale University; Milner B. Schaefer, Inter-American Tropical Tuna Commission; and Athelstan Spilhaus, Institute of Technology, University of Minnesota.

COMMITTEE REPORT

The first meeting of this group, held in November, 1957, was followed by week-end meetings approximately every two months. The Committee met at several of the centers of oceanography in the United States in order to become more fully acquainted with the local problems as well as the national needs.

In February of 1959, a summary of the findings of the Committee was released to the Gov-

ernment agencies sponsoring the study, to the Congress, and to the public. The essence of the Committee's recommendations are contained in a short section from Chapter I headed *General Recommendations* which follows.

"The key to the growth of oceanography in the United States lies in basic research—research which is done for its own sake without thought of specific practical applications. The very nature of basic research is such that the problem which will be attacked and the results which will be obtained cannot be predicted. The very nature of applied research is such that its success depends upon the size of the reservoir of fundamental knowledge upon which it must draw. The rate of progress in the applied marine sciences will be determined in the long run by the rate of progress in the basic marine sciences.

"The Committee has concluded that both the quantity and quality of basic research in the marine sciences can and should be increased substantially during the years ahead. Specifically the Committee recommends:

"The United States Government should expand its support of the marine sciences at a rate which will result in at least a doubling of basic research activity during the next ten years."*

"It should be emphasized that doubling the basic research activity will require more than doubling the total expenditures.

"A large part of the deliberations of the Committee were devoted to discussions of the conditions under which basic research can flourish. First and foremost, progress depends upon the interests, experience and creative imaginations of individual scientists. But the individual scientist does not work in a vacuum. He must have instruments and facilities. He must live in an atmosphere which is conducive to creative activity. These necessities in turn give rise to problems involving marine research laboratories—problems of leadership, financial stability, flexibility, growth, academic associations and physical facilities.

"Not only for research but in order to exploit and use the oceans we need more detailed knowledge which can be obtained only through

systematic surveys in three dimensions. These surveys should include such features as depth, salinity, temperature, current velocity, wave motion, magnetism, and biological activity. It is essential that these surveys be conducted on an ocean-wide ocean-deep basis as quickly as possible. Our knowledge is now limited largely to waters 100 miles from shore and even here it is inadequate for present and future needs. Accordingly, the Committee recommends:

"The increase in support of basic research should be accompanied during the next ten years by a new program of ocean-wide surveys. This will require a two-fold expansion of the present surveying effort."

"We believe that, on a long-range basis, basic research coupled with systematic ocean surveys are of paramount importance in solving a number of urgent practical problems involving military defense, the development of ocean resources and possible future increases of radioactive contamination of the seas resulting from the rapid development of atomic energy. However, research and surveys must go hand in hand with a vigorous and imaginative applied research and development program. Accordingly the Committee recommends:

"The United States should expand considerably its support of the applied marine sciences, particularly in the areas of military defense, marine resources, and marine radioactivity."

"The implementation of these general recommendations requires action upon a number of broad fronts. More marine scientists must be educated. Additional ships and shore facilities must be built. New instruments and techniques must be developed. International cooperation in the marine sciences must be strengthened.

"To achieve these aims in the next ten years will necessitate many agencies of the Federal Government working together both in planning and in providing the monies*. Taking into account the relative degrees of interest and importance of oceanography to individual agencies, the Committee recommends:

"The Navy and the National Science Founda-

*In 1958 about 23 million dollars were spent for applied and basic oceanographic research. The basic research share of the total was not over 9 million. About 8 million of this, including the 1958 share of IGY expenditures, were Federal funds.

*One method suggested for developing more effective inter-agency cooperation is through the proposed Federal Council for Science and Technology. This Council is described in *Strengthening American Science*, a recent report of the President's Science Advisory Committee.

tion should each finance about 50% of the new basic research activity except ship construction. The Navy should finance 50% of the new research-ship construction with the Maritime Administration and the National Science Foundation sharing the remainder. The Navy, through the Hydrographic Office, should finance 50% of the deep ocean surveys, while the Coast and Geodetic Survey should finance the balance. The Navy should sponsor completely all military research and development operations. The Bureau of Commercial Fisheries should finance the greater part of the recommended ocean resources program. The Atomic Energy Commission should finance the major part of the research dealing with the problems of radioactive contamination of the oceans. The National Science Foundation and the Office of Education should sponsor jointly the proposed program for increasing scientific and technical manpower in the marine sciences. Efforts aimed at fostering international cooperation in the marine sciences should be sponsored by the Department of State, the International Cooperation Administration and the National Science Foundation. Other agencies should take responsibility for certain aspects of the proposed program, particularly the Public Health Service, the Geological Survey and the Bureau of Mines.

"Although the bulk of oceanographic research and survey work must of necessity be financed by the Federal Government, the value of state and private funds cannot be overestimated. Such funds are especially helpful for supporting initial exploratory basic research and for starting new laboratories. Accordingly, the Committee recommends:

"Private foundations and universities, industry, and state governments should all take an active part in the recommended program of expansion."

The Committee's task in arriving at the above recommendations was not an easy one. As pointed out in its report, the broad field of scientific endeavor covered by the term "oceanography" introduced many complications. In its study, the Committee considered that oceanography could be defined as "the scientific study of all aspects of the oceans, their boundaries and their contents." Research is undertaken in a variety of private and Government laboratories; numerous Government agencies have direct

but differing interests in the oceans. Indeed the breadth of the problems and subjects discussed was such that in the Committee's mind the terms "oceanography" and "marine sciences" are synonymous. Thus equal emphasis is placed upon the requirements of marine biology, physical oceanography, geology, chemistry, and the application of basic knowledge to special developmental problems.

In order to make recommendations under these circumstances, the following panels were formed for the purpose of making specific studies: *Panel on Oceanographic Research Ships*, Clifford A. Barnes, Admiral L. O. Colbert, John Isaacs, Columbus O'D. Iselin (Chairman), Vito Russo, and Herbert Seward; *Panel on New Devices for Exploring the Ocean*, Robert Frosch, James Lipp, Philip Mandel, Andreas Rehnitz, Athelstan Spilhaus, Allyn Vine (Chairman), and Rear Admiral George Weaver; *Panel on Ocean Resources*, Richard L. Meier, H. W. Menard, John R. Menke, Milner B. Schaefer, Oscar E. Sette, Robert G. Snider (Chairman), Lionel A. Walford, and R. F. Nigrelli (Consultant); *Panel on International Cooperation in the Marine Sciences*, Columbus O'D. Iselin, Fritz Koezy, Roger Revelle, Milner B. Schaefer, and Athelstan Spilhaus (Chairman); *Panel on Radioactivity in the Oceans*, Howard Boroughs, Dayton Carritt, Walter Chipman, Harmon Craig, Lauren Donaldson, Richard Fleming, Richard Foster, Edward Goldberg, John Harley, Bostwick Ketchum, Louis Krumholz, Charles E. Renn, Roger Revelle (Chairman), Milner B. Schaefer, Allyn Vine, Lionel Walford, and Warren Wooster, with consultants: Theodore Folsom, Arnold Joseph, Robert Reid, and Donald Pritchard.

Although the total amount of money needed for the ten-year program outlined by the Committee appears large, the actual recommended rate of increase of basic research activity compared to the present level is somewhat less than 10% per year. The major expenditures required in the next few years are for the modernization and the long over-due replacement of old obsolete ships and facilities.

The essential limitation on the rate at which the marine sciences can expand effectively is that of available manpower. This point is stressed in the report by a series of specific recommendations on the need for additional financial

support of faculty and graduate students in oceanography. The major problem of the Committee in formulating its recommended program was to balance the urgent need for rapid expansion against a reasonable rate of growth consistent both with the acquisition of well-trained and competent scientists and with an orderly expansion of existing laboratories and the development of new ones. Foremost in the minds of the Committee was the need to meet the current and future urgent needs for oceanographic knowledge and to avoid the necessity for a costly "crash" program at some future date. Indeed, the report stresses that the recommendations contained in it are considered to be minimal and that "action on a scale appreciably less than that recommended will jeopardize the position of oceanography in the United States relative to the position of the science in other major nations, thereby accentuating serious military and political dangers, and placing the nation at a disadvantage in the future use of the resources of the sea."

The first chapter of the Committee's report, released in February, 1959, contains the general recommendations listed above and a series of specific recommendations on Education and Manpower, New Ships, Shore Facilities for Basic Research, Ocean-wide Surveys, Engineering Needs, Radioactivity, Ocean Resources, International Cooperation, and Budget and Operations. More detailed discussions and information on each of the above subjects is being provided through a series of eleven supplemental chapters covering the subjects listed above plus Basic Research, Oceanographic Research for Defense Applications, a History of Oceanography in the United States, and a review of the Status of Marine Sciences in the United States as of 1958. Most of these chapters will have been finished and distributed by the time this article is published.

Although fairly detailed in some sections, particularly in describing the requirements for types of activities needed in ocean resources research, the report does not go into detail in describing fundamental basic research which can be carried out only under the inspired leadership of individual scientists. The report does not provide specific details on exactly how particular types of apparatus should be developed and constructed, but the general require-

ments for new instrumentation are discussed. The report does not judge the relative merit of one institution as opposed to another or in any way attempt to pass judgment on specific scientific research projects, nor does it cover all specialties in the marine sciences, such as coastal geography, marine deterioration, etc. The goal throughout the report is to encourage as much freedom as possible in individual scientific pursuits and to construct the framework within which a vigorous, healthy, imaginative national program in the marine sciences can grow.

REACTION TO THE COMMITTEE REPORT

The public interest and reaction to the report of the Committee on Oceanography far exceeded the expectations of the members of the Committee. Because of the very broad recommendations contained in the report, the Committee felt a quadruple responsibility to make its findings known to the Government sponsors of the Committee, to other branches of the Government, to the scientific community, and to the general public. The response in each of these areas has been and continues to be gratifying.

Government agencies—Almost simultaneous with the release of Chapter I of the Committee on Oceanography report, an internal Navy document, PROJECT TENOC, prepared by the Office of Naval Research, received strong endorsement from Admiral Arleigh E. Burke, Chief of Naval Operations. This project, independently derived by the Office of Naval Research, outlines the requirements for ship construction, laboratory construction, and the support of oceanographic research needed to meet the rapidly expanding needs of the Navy for oceanographic information over the period of the next ten years. The general similarity in terms of funds, numbers of ships and laboratories contained in the PROJECT TENOC report with that portion of the same types of activities assigned to the Navy in the Committee on Oceanography's report tends to confirm the realistic appraisal of the needs and objectives achieved by both groups. The Navy has been and obviously will continue to be one of the strongest supporters of basic and applied oceanographic research in the United States. As one indication of the Navy's interest, the budget for fiscal year 1960 contains funds for the construction of a special oceanographic research

ship. This will be the first oceanographic research ship specifically designed and constructed for oceanographic research by the United States Government. The last ship built and designed for this particular purpose in the United States was the *Atlantis* of the Woods Hole Oceanographic Institution, now over 29 years old. In addition to making funds available for the construction of a new ship, the Navy has recently converted three ships for oceanographic research: the 2000-ton *Chain*, now at the Woods Hole Oceanographic Institution, the 2700-ton *Gibbs* now at the Hudson Laboratory, and the 2000-ton *Snatch*, soon to be in service at the Scripps Institution of Oceanography. In addition to this substantial support of facilities in terms of ships, the Navy has increased its support of basic and applied oceanographic research by an appreciable amount.

Other Government agencies also have responded to the additional needs for oceanographic research. The National Science Foundation has obtained funds for an oceanographic research ship and in all agencies there has been an expansion in either the actual or planned support for oceanographic activities.

One of the peculiar problems of oceanography in the development of a nation-wide program is the number of agencies of the Federal Government having direct and indirect interests in such a program. Even before the Committee on Oceanography was organized, the need for coordination in planning various activities was recognized by personnel in these agencies. To meet this need an informal coordinating committee on oceanography has been holding monthly meetings in Washington for several years. Prior to the release of the Report of the Committee on Oceanography, the membership of this group consisted mainly of personnel from the Office of Naval Research, the U. S. Hydrographic Office, the Bureau of Commercial Fisheries, the Atomic Energy Commission, and the National Science Foundation. This group now consists of representatives from these agencies plus the Beach Erosion Board, Department of Health, Education, and Welfare, U. S. Coast Guard, U. S. Geological Survey, Bureau of Mines, Weather Bureau, State Department, Air Force, Maritime Administration, Bureau of Ordnance, Military Sea Transport Service, etc. These men function as a very effective working

group in the coordination and planning of programs in each of these agencies. However, in order to embark upon a program of the magnitude visualized in the Report, some mechanism seemed necessary whereby the Executive Branch of the Government could make a policy decision on the need for such a program. With the completion of a special report prepared under the leadership of Dr. Killian, first Chairman of the President's Scientific Advisory Committee, a Federal Council on Science and Technology has been established. This Council consists of heads of each of the Government agencies which have scientific programs. One of the first acts of this Council was to appoint a Special Subcommittee on Oceanography, consisting of one individual each from the Department of Defense, the Department of Commerce, the Department of Interior, Atomic Energy Commission, and National Science Foundation. Mr. Wakelin, Assistant Secretary of Defense for Research and Development, is Chairman of this Special Subcommittee. Under his leadership, the Subcommittee is conducting an intensive study of the Report of the Committee on Oceanography and the extent to which it meets the needs of the Government agencies. It is too early to tell yet what the results of the activities of this group will be. However, the enthusiasm and the seriousness with which they are studying the recommendations of the Committee on Oceanography is an indication of their concern over this problem. Thus we see a mechanism based on a large informal group at the working level in Government agencies working through a high level executive advisory committee to assist the executive branch in making administrative decisions regarding the need to support a particular branch of science. To some extent, this constitutes a new experiment in the design of a mechanism for development and administration of a program affecting many Federal agencies. Heretofore, a single agency has been assigned primary responsibility for budgeting and for carrying out a program. In the marine sciences, the responsibilities are so broad as to seem to preclude this solution, and instead to require some form of flexible joint planning and coordination.

Congress—Only a few days after the release of the Committee's Report in February, Congressman Herbert Bonner, Chairman of the

House Committee on Merchant Marine and Fisheries, announced the formation of a Special Subcommittee on Oceanography. This Subcommittee, although contemplated earlier by Mr. Bonner, was undoubtedly a direct response to the challenge presented in the Committee's Report for the development of a national marine sciences program. Mr. Bonner appointed Congressman George Miller of California as Chairman of this Special Subcommittee. Mr. Miller held a series of hearings during the spring and early summer of this year to establish background information on the existing oceanographic programs in the various Federal agencies and their plans for the future. Other members of the Subcommittee are: Willard S. Curtin (Pa.), John D. Dingell (Mich.), Francis E. Dorn (N. Y.), Gerald T. Flynn (Wisc.), Alton Lennon (N. C.), James Oliver (Maine), and Thomas M. Pelley (Wash.).

After hearing testimony from all the agencies primarily concerned with marine sciences, some members of Mr. Miller's committee made a short visit to the Woods Hole Oceanographic Institution and attended part of a meeting of the Committee on Oceanography to obtain more insight into the philosophy and requirements of oceanography. Their activities during the next session should be of considerable interest to all oceanographers.

One other committee in the House, the House Committee on Science and Astronautics, has expressed a special interest in the Report. Congressman Brooks, Chairman of this Committee, introduced a bill early this year calling for special fellowships under NSF sponsorship for students in oceanography. Although the passage of this bill in its present form, or possibly even modified, seems doubtful, the hearing on the bill held during August of this year marked the first meeting of a new Subcommittee on Earth Sciences of the House Committee on Science and Astronautics. Mr. Brooks is chairman of this special Subcommittee and other members are: Perkins Bass (N. H.), J. Edgar Chenoweth (Colo.), Ken Hechler (W. Va.), Joseph E. Karth (Minn.), R. Walter Riehlman (N. Y.), and B. F. Sisk (Calif.). This group plans to consider the needs of all of the Earth sciences at future hearings.

In the Senate, the Committee's Report re-

ceived almost immediate support from Senator Humphrey, who read the report into the Congressional Record, along with a strong statement of endorsement. In June, Senators Magnuson, Jackson, and Engle submitted a resolution to the Interstate and Foreign Commerce Committee calling the Committee on Oceanography's Report to the attention of the President and the Government agencies, and endorsing the need for effective action. Later this resolution with the sponsorship of the full Interstate and Foreign Commerce Committee was passed unanimously by the Senate.

One of the recommendations of the Report is that the Coast and Geodetic Survey join with the Navy in an ocean-wide, ocean-deep survey program. Since the charter of the Survey implies a restriction of the activities of that agency to the coastal waters of the United States, some legislation is required to permit effective operation by the Survey in deep oceanic waters. A bill to achieve this has been introduced and passed by the Senate. Similar legislation is under preparation by the House. However, the House did not act on the bill during the first session. Whether or not additional legislation is required to enable the Government agencies to expand their oceanographic activities remains to be seen. In general, the authority already exists for participation by any agency in that part of the program outlined by the Report. However, those smaller agencies which make up a fractional part of the interests and activities of larger departments of the Government doubtless will have an extremely difficult time in expanding their scope of participation except as a part of an overall coordinated program backed by the Executive and Legislative branches of the government. During the closing days of the 1959 Congressional session Senator Magnuson introduced a bill, S.2692, entitled *Marine Sciences and Research Act of 1959*. This bill, sponsored by 13 Senators, is now in the Interstate and Foreign Commerce Committee. Hearings are planned on the bill during the next session of Congress.

The inquiries and expressions of interest and support from Congress have been numerous. One thing seems certain: top-level Government administrators will have to be convinced not only of the necessity of the program outlined

by the Committee but also of the fact that the program will be carried out as efficiently as possible, and with complete inter-agency cooperation.

Scientific response—The response of the scientific community has varied from complete endorsement to annoyance at the fact that a particular specialty of marine sciences has not been covered in the report and suspicion over the wisdom of placing particular attention on a special field of science. It is, of course, gratifying to have the approval of our scientific colleagues. The disapproving reactions seem to be based either on a lack of understanding of the objectives of the Report (that is the areas of interest covered and the motivations for preparing the report), or difference of opinion as to the mechanism for making Government policy regarding the support of science. After months of deliberation the Committee decided to emphasize those parts of oceanography which are of major concern to the well-rounded development of a national marine sciences program. For example, this meant emphasizing the construction of ocean-going research ships to replace existing obsolete vessels and build up our capability for research in the open oceans, while underemphasizing the need for ships for coastal research. It also meant stressing large programs of ocean surveying and construction of special large facilities for controlled environmental studies. Such large programs cannot be supported by a single institution, but require adequate backing on a national scale. Thus, many details of the type of research needed and capable of being carried out by smaller institutions in coastal waters of the United States were not specifically covered in the Report although the overall expansion necessary to develop a well rounded program would also include an increase in this type of activity.

Under its two charters, the first signed by Abraham Lincoln during the Civil War which established the National Academy of Sciences, and the second signed by President Wilson during the first World War establishing the National Research Council, the NAS — NRC has a direct responsibility to advise the Government on matters pertaining to science. The recent establishment of a Federal Council on Science and Technology is an additional indi-

cation of the extent to which scientists must participate in formulating and advising the Government on matters of national importance. It seems there can be little doubt that the future development of our nation's capabilities in the marine sciences is a matter of concern not only to oceanographers and the Government, but also to the public.

Public response—A graph of the number of words contained in popular articles on oceanography would, we believe, show an abrupt increase starting in 1959. A large part of this interest probably was generated by the publication of the Report on Oceanography. However, equally important may be the growing realization among laymen that man is not soon to escape his troubles by joining an expedition to outer space. Few scientists are more excited by and interested in the prospects of exploring outer space than those that make up the membership of the Committee on Oceanography. Indeed, the Committee's Chairman is also a member of the Academy's Space Science Board. We certainly do not discount the importance of a vigorous program of space exploration and research. However, for the billions of persons who now inhabit the Earth, space can provide only an exciting diversion from the practical problems of survival and subsistence. The realization of this fact and the vast unknown and unexplored riches of the oceans undoubtedly accounts for the growing public interest in this forgotten frontier.

During 1959, two national news magazines, *Newsweek* and *Time*, ran feature stories on oceanography and the program of the Committee. At the writing of this report, a feature story is under preparation for *Fortune* Magazine on this subject. Articles have appeared in Sunday supplement magazines (as well as in the Sunday comic sections) and a high school student weekly news study guide. The daily press has been a frequent source of stories concerning the potentialities of the oceans. Surely no literate American will have gotten through 1959 without seeing the word "oceanography" at least once. Even the *Reader's Digest* published in a recent issue a condensation of the *Time* feature story, and *Coronet* magazine is expected to have a feature story before the end of the year. One popular report prepared

by the Committee, and written by Dr. Athelstan Spilhaus, titled *Turn to the Sea* was released in August and has had to be reprinted because of the unexpectedly enthusiastic demand for copies.

This response and interest seems to be a positive sign that the legislators will receive support on the home front for any additional funds they may appropriate for the marine sciences.

THE FUTURE

The Committee hopes that its Report will stimulate an exhaustive appraisal by all of those involved in the marine sciences as to their own programs, the plans and ambitions

of their agencies and institutions. Our future progress can be only as good and as well planned as the scientists in the marine laboratories can make it and as ambitious as those in authority are willing to support. In its present form the Report is neither the perfect nor the last word in critical appraisal of the problems, potentialities, and methods for development of the marine sciences. Honest and objective criticism, personal thought and discussion, group discussions of objectives and methods are needed in great detail to realize the objective of an adequate development of this field which is so important to the security, well being and scientific development of our nation.

Antarctica

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Nowhere in the world during the past four years have advancements of knowledge been so rapid, scientific discoveries so routine, or international cooperation and coordination so much in evidence as in Antarctica. Our knowledge of this great continent has increased manifold in this period, and this advance shows no sign of diminishing. Even as this article is being written, new areas are being explored by over-snow vehicles in the interior and by ships along the coasts, and new scientific stations are being planned.

INTERNATIONAL GEOPHYSICAL YEAR

The attack on Antarctica was the result of the International Geophysical Year program, the world-wide joint efforts by 66 nations on the global scientific problems concerning the Earth. The two most spectacular achievements of this coordinated program were the break-through of missiles from the immediate Earth gravity attraction and the occupation of Antarctica. The satellite program was, however, more a speeding up and inevitable extension of rocket programs initiated during the war years. In Antarctica, the effort was unprecedented. Though implications of political nature were always present, and, no doubt, dictated many of the international moves, this competition was not without merit and served to deepen the interest and insure the progress of Antarctic scientific knowledge.

The continent of Antarctica, from the beginning of the IGY planning, held a dominant role. The southern hemisphere with a small fraction of the world's land areas and the world's population, contained a large fraction of the unknown problems of global geophysical knowledge. The move south across the equator was thus an obvious need that commanded major attention in the IGY programs of all scientific

disciplines. Island stations of the South Pacific, South Atlantic, and Indian Oceans, where possible, were occupied in an effort to link together the results from land stations of South America, Africa, Australia and New Zealand, but these islands are few and far apart and many are not easily accessible. Thus the continent of Antarctica, with 29% of all land area south of the equator, however inhospitable, was important for the coordination of efforts in the southern hemisphere. In addition the south magnetic pole is in Antarctica, and the programs of the upper-atmospheric disciplines are in a large measure directly or indirectly influenced by the magnetic properties of the Earth.

The importance of Antarctica in the IGY planning, the natural obstacles to establishing bases even in the more accessible areas, and the international politics involved, led early in the planning to special consideration, first in the 1954 CSAGI Conference in Rome, then to the regional conferences on Antarctica in Paris in 1955, 1956, and 1957. At the first of these Antarctic conferences, the mutual problems and interests of the participating countries were discussed and optimum distribution of stations considered. In the United States a special Antarctic Committee under Dr. L. M. Gould was formed to coordinate the various Antarctic disciplines and consider the implementation of logistic requirements of the scientific interests of the United States. For this tremendous logistic task, the U. S. Navy was given responsibility, and Task Force 43 was organized under the command of Admiral George J. Dufek. Foreseeing the need for bringing our scientific knowledge of Antarctica up to date, Dr. Gould convened an Antarctic symposium which was held in Washington in April, 1956. A score of speakers discussed the status of Antarctic science and the prospective plans and

expectations for the future IGY program. The collective papers were published as the first of the American Geophysical Union Monographs and represented, for the planning and operating scientists, an excellent handbook of Antarctic science.

Antarctic Accomplishments, 1955 to 1959

Logistics—It is not the purpose of this article to elaborate on the details of the active years of IGY operations in Antarctica. Five U. S. scientific stations, a joint U. S.—New Zealand scientific station, and a U. S. Navy operational base were established by early 1957 and scientific observations were under way even before the official commencement of IGY on July 1, 1957. At the same time, other nations were establishing 13 new bases, including an interior one by France and eventually three interior ones by USSR though extreme conditions in the interior in this area of Antarctica delayed final occupation. The purpose here is, in a condensed space, to look in retrospect after nearly four years to see what has been accomplished and what scientific knowledge has evolved.

Foremost, let us view the logistic ground that has been gained. As in the satellite operation where the scientist must wait for the engineer to provide him with the vehicle, so in Antarctica the scientist turned to the U. S. Navy to build a home for him and for his equipment. These logistic tasks were not easily accomplished in this hostile continent. This most fundamental problem has been successfully accomplished and becomes perhaps the greatest single accomplishment in Antarctica; the establishment of permanent operating stations, even to the heart of the Continent.

This struggle was centered on three transportation vehicles; the icebreaker, the airplane, and the tractor. The icebreaker cleared a path through the ring of ice around the continent to the shores, leading in conventional cargo ships with fuel, food, and building material. To carry these supplies inland to the South Pole Station, the U. S. Air Force brought in C-124 Globemaster planes and, using the McMurdo Bay ice as a runway, paratropped tons of material, following the first pole landings by Navy ski-equipped aircraft. To supply the inland Byrd Station, a united effort was made between the

paradrops of the Globemasters and trains of giant D-8 Caterpillar tractors carrying supplies inland from the Little America Station over 650 miles of trail blazed by Arctic specialists of the U. S. Army. For the first time in Antarctic history permanent bases were located in the inland areas of the Continent, one of these supplied entirely by air, and for the first time tractor supply trains moved well into the Antarctic interior. A further logistic achievement was the establishment of a radio communication network linking the U. S. and other Antarctic stations together and tying this network back to world operating centers.

Scientific—With the stations adequately located (Fig. 1), the U. S. scientists numbering nearly one hundred each season, were able to join with scientists from other nations to carry out the tasks assigned them by the IGY discipline program directors. The volume of data which has slowly accumulated is difficult to imagine. According to Dr. Harry Wexler, Chief Scientist of the Antarctic Program during IGY, at least ten years will be required to evaluate the findings completely, despite the essential use of electronic computers and other machine aids. However, it is not too early to form an evaluation of the general scientific achievements and preliminary results. In Wellington, New Zealand, in February, 1958, the first International Symposium dealing with Antarctic research was held. Though conceived primarily as a means of allowing informal discussions between scientists that had been operating in the field during the initial stages of IGY, it covered many preliminary results and successfully achieved coordination and standardization of operations. In November, 1959, a more comprehensive international symposium will be held in Buenos Aires. Final results of many phases of all disciplines will be presented.

The Antarctic scientific operations can be roughly divided into two categories. In the first, the observations taken form a necessary supplement to world-wide data, a part of the global look at particular phenomena. In this grouping belong the solid-earth sciences such as gravity and earthquake seismology, also oceanography, meteorology, and the upper atmosphere sciences; and geomagnetism, ionospheric physics, aurora, and cosmic rays.

The second group is more intimately con-

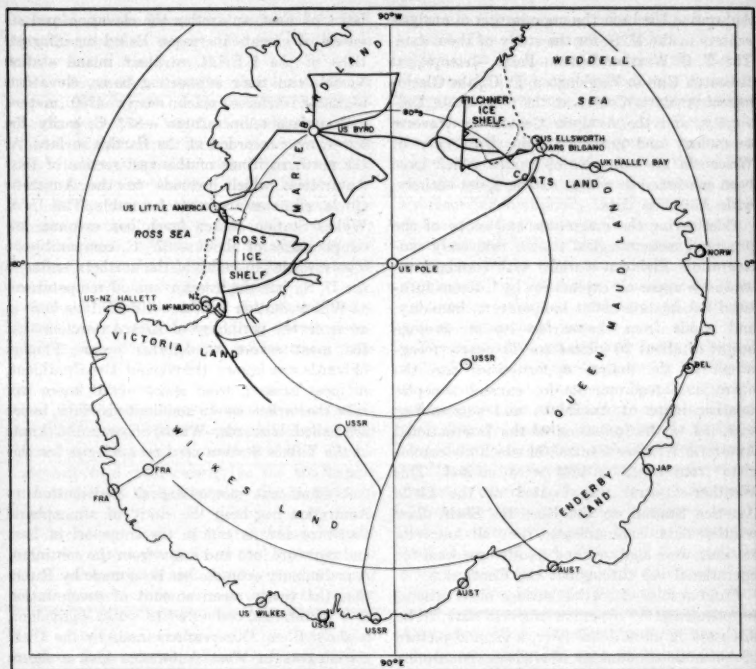


FIG. 1—Antarctic stations and traverses during IGY

nected with the Antarctic continent itself. Foremost here is the study of glaciology. As the one substance most characterizing Antarctica is ice and as Antarctica contains 90% of the world's ice, the Continent's major problems are glaciological problems. Earthquake seismology and some phases of gravity also contribute to the underlying structure as well as forming a network of worldwide observations. Then, of course, many of the global sciences, particularly meteorology and oceanography, are influenced to such an extent by the continent that special Antarctic studies are necessary. Also, sciences like biology and geology, though not included in IGY disciplines, are concerned with the unique features and character of Antarctic flora, fauna, and constituent rocks.

In the sciences dealing with global distribution, the lag between data collection and final analysis must of necessity be several years. The free interchange of geophysical information between countries was a most important principle of the IGY. Data centers were set up for the collection and dissemination of all IGY collected information. It will be obvious in the discussions to follow that concentrated attention will fall at this time on the local aspects of the global sciences and on the individual efforts in sciences such as glaciology where (though international coordination of data will eventually come through the analysis of area reports) many individual reports will be complete in themselves.

Concurrent with scientific data collection in

Antarctica has been the organization of analysis centers in the U. S. for the study of these data. The U. S. Weather Bureau Polar Meteorological Research Unit in Washington, D. C., the Glaciological Analysis Center at the Ohio State University, and the Analysis Center for traverse seismology and gravity at the University of Wisconsin are examples of groups which have been concerned to a large extent, if not entirely, with Antarctic data.

Considering the magnitude and scope of the program, meteorological studies rate early consideration. Eighteen stations with standard rawinsonde upper-air exploration by balloons furnished information about temperature, humidity, and winds from the surface to an average height of about 20 kilometers. The early recognition of the unique opportunities and the operational requirements for current synoptic weather maps of Antarctica and surrounding seas, led to the formation of the International Antarctic Weather Central, in which meteorologists from other nations were invited. This Weather Central was located at the Little America Station on the Ross Ice Shelf. Raw weather data, communicated from all Antarctic stations, were analyzed and results broadcast for operational use throughout the Continent.

From results of station surface observations, supplemented by oversnow traverse data, to be discussed in more detail later, a general picture of Antarctic climatology is available. Antarctica consists of two quite dissimilar areas: West Antarctica, the region facing north to the western hemisphere and Pacific Ocean, has surfaces up to 2000 meters above sea level and includes two vast low-lying ice shelves. In this area neither the temperatures nor winds are extreme for Antarctica. Temperatures average down to about -30°C with extreme cold temperatures rarely below -56°C . The U. S. Byrd Station, centered in this West Antarctic province, has provided us with a most comprehensive picture of this part of Antarctic upland. The East Antarctic region, considerably larger in size, is higher in elevation and is colder. The U. S. South Pole Station is on the outlying part of this area, and has an elevation of about 2900 meters and an average annual temperature of -50°C . The lowest surface temperature at the South Pole Station was -76°C . Going inland toward the

heart of East Antarctica the elevation and severity of climate increases. Based on information of the U.S.S.R. at their inland station Vostok and their supporting bases, elevations of snow surfaces reach nearly 4250 meters, and surface temperatures -87°C , easily the lowest ever recorded at the Earth's surface. At the northern fringe of this vast section of East Antarctica, which extends to the Antarctic Circle, climates are more favorable. The U. S. Wilkes Station at sea level, has extreme low temperatures of about -37°C , comparable to lows recorded in many of the northern states in the U. S., but the average annual temperatures at Wilkes Station is near -10°C . It is here in areas on the periphery of East Antarctica that the most severe windstorms occur. Though blizzards are known throughout the Continent, in most areas a wind speed of 20 knots will raise the surface snows and limit visibility, hence are called blizzards. Winds of over 100 knots at the Wilkes Station need no apologies for this term.

A significant meteorological contribution to Antarctica has been the study of atmospheric structure and its role in the transport of heat and moisture into and away from the continent. A preliminary estimate has been made by Rubin that the yearly mean amount of precipitation over Antarctica, converted to water equivalent, is about 6 cm. Observations made by the U. S. glaciologists in West Antarctica give a figure two to three times that amount, so that precipitation over the vast areas of East Antarctica must be very low, indeed.

Other meteorological analyses include the structure of the Antarctic stratosphere with its sudden warming in late October and early November, the anomalous maximum of ozone at Little America during the winter in the absence of sunlight, and comparisons of these phenomena with Arctic patterns.

In the upper-atmosphere physics studies, the combined results of many stations are also needed before evaluation can be completed. Ionospheric soundings and geomagnetic variations have been subjects of study over large fractions of the world many years before IGY. Thus, the observing techniques of routine observations were quite well developed. Although aurora studies, particularly in the northern

hemisphere, have been made for decades, IGY furnished the first opportunity for coordinated efforts in the Antarctic.

The South Pole Station occupies a unique and important part in the study of the atmospheric phenomena which deal with solar-terrestrial relationships. This is particularly true since its counterpart in the Arctic is in the Arctic Ocean where a fixed station is not possible. At the south pole the Sun is below the horizon for the longest possible time, and here the variations of altitude of the Sun are the smallest. It is the most ideal site for studies concerned with the twilight period.

Auroral observations from the Antarctic continent have now succeeded in locating the auroral zone. This zone lies inside an arc passing through Byrd Station, very near the Pole Station and about 300 km west of Wilkes Station. A diurnal motion of auroral distribution has also been noted at the south pole, believed caused by the apparent motion of the Earth's magnetic field with respect to the south pole and the Sun, thus implying also a seasonal effect.

Correlation of the northern aurora borealis with the aurora australis of the Antarctic and surrounding area is not directly possible since the Antarctic auroras are seen during the winter months, May to August, when high Arctic areas have maximum sunshine. Correlations made between data from the Antarctic Ellsworth Station and the St. Lawrence River area in the north, have shown that in practically all cases the aurora occur simultaneously in both areas though the details may be quite different.

Ionosphere studies, like those of the aurora, have benefitted from the Antarctic results. At the south pole, contrary to expectations, consistent diurnal variations were observed throughout the year. The analysis of these and other variables, particularly in the absence of sunlight, will add much to the understanding of the ionized atmosphere. In the study of ionospheres: The whistlers, dawn choruses, and *vf* emissions that originate in the ionosphere and follow the flux of the Earth's magnetic field above the Earth and to a symmetrical point in the opposite hemisphere, the area of West Antarctica and the Palmer peninsula are conjugate areas for eastern United States where high thunder-

storm activity occurs and where there is a high concentration of monitoring stations.

The geomagnetic stations record the Earth's magnetic field and its variations, the variations being generally caused by movement of ionized currents of the upper atmosphere. Here again, the Antarctic has been important because so many stations could be located in the vicinity of, and particularly inside, the auroral zone. By recording continually the fluctuations of the magnetic-field components through a broad band of frequencies (50 cycles per second to one cycle per year), these results will allow close comparison of the times of magnetic storm characteristics between stations, and with auroral and ionosphere data.

The sciences of gravity and earthquake seismology, though primarily of use in world-wide studies of the shape of the Earth and earthquake epicenter distribution, contain aspects that directly concern Antarctica. It is hoped that details of gravity anomalies will furnish information on isostatic compensation of the Antarctic continent, that is, on the adjustment of stresses that have been produced in the Earth's crust and mantle by the tremendous load of ice, and past changes of this load. Results discussed in London early this year of the British Trans-Antarctic Expedition have indicated negative anomalies of 200 mgal in East Antarctica. More extensive results of the U. S. efforts are yet under analysis but preliminary data does not entirely confirm this high a gravity anomaly.

The earthquake seismograph stations on the Continent have assisted in locations of earthquake epicenters, particularly in the southern hemisphere. The results have also contributed, from study of records of earthquakes located near Antarctica, to the knowledge of the sub-structure of the Continent. Data from the Wilkes Station, analyzed at California Institute of Technology; and data from the Hallett and Scott bases studied in New Zealand, both indicate that a true continent exists but that it may be limited to East Antarctica. Perhaps, unfortunately for this study, the general Antarctic area is rather quiet seismically, and only a few earthquakes have occurred which can aid in the study of the continental sub-structure.

Oceanographic studies in the seas around

Antarctica have included standard observations of water temperature, salinity, and oxygen content; ocean currents; depths of water and study of marine life, obtained from the U. S. Navy icebreakers. As these ships are not equipped as oceanographic research vessels, beside having heavy logistic obligations, little time could be spared for concerted efforts in oceanography. The U. S. oceanographic research ships, limited to a few hundred tons, are unsuitable for operations in the high southern latitudes. Despite these factors, oceanographic data collected has been quite extensive and has added considerably to our knowledge of the waters surrounding the Continent.

Antarctica was a special concern of the IGY glaciological working group and considerable planning went into this relatively new type of program. The questions that needed answers were relatively simple: What is the extent, elevation, and volume of the Antarctic ice? What would be the appearance of Antarctica without its ice cover? How much snow falls annually on Antarctica and what becomes of this snow? Is it slowly building up the continent or does the annual evaporation, formation of icebergs, and melting by sea water balance this accumulation, or even over-balance it and thus decrease annually the amount of Antarctic ice?

The other aspect involved the history of the continent of ice. Were changes in Antarctica synchronous with the glacial ages in the northern hemisphere? When did Antarctica start accumulating its ice?

The answers to these questions can only be inferred through many types of observations at many sites. At the stations, observations were made of the amount of accumulation and motion studies were initiated. In most cases, the motion studies, which can give estimates of the balance of the ice budget, will take several years because of the very slow ice movements. Perhaps the most important of the glaciological studies were carried out on inland traverses. During each of two summers during the IGY period, traverses involving five or six personnel each, radiated from Little America, Byrd and Ellsworth Stations. Covering in all some 12,000 km over inland ice, explorations of the Filchner Ice Shelf, Byrd Land, Ross Ice Shelf, and Victoria Land were made. During these traverses, many subjects were studied; elevations

of the surface by altimetry, ice thickness by seismic soundings, annual accumulation by examination of snow characteristics in shallow pits, gravity and magnetics, surface weather, temperatures in deep bore holes to get average annual surface temperatures, and reconnaissance geology and biology where feasible. Along the route of these operations, many new mountain ranges were located.

Study of the past history of the Antarctic ice has been started through glacial geology in ice-free areas, examination of ice cores obtained to 300 meters at Byrd Station and to 250 meters at the Little America Station, and special observations such as carbon 14 analysis, thermoluminescence, biological studies, and studies of ocean sediments.

The picture that is slowly evolving as a result of the analysis of the glaciological studies is the first clear one of Antarctica. West Antarctica, with the snow cover removed would be an archipelago of scattered mountainous islands. A great part of this area would be under water even allowing for isostatic rise of land following release of the burden of ice. With heights of the surface generally from 1000 to 2000 meters above sea level, ice thicknesses range from 1500 to 3500 meters, and, in one isolated site, over 4000 meters. The Filchner Ice Shelf in the Weddell Sea area was found to be quite extensive, nearly as large as the Ross Ice Shelf. This better-known feature was studied in some detail, and, as expected, it was found to be nearly completely floating over relatively deep water. Under both of these shelves, deep troughs were located, the deepest being under the Ross Shelf area not far south of Mount Discovery, where the ocean floor lay nearly 1400 meters below sea level. The thickness of these floating shelves over the deep water can be quite large. Values of over 900 meters were obtained near the Lív Glacier, and ice is probably even thicker east of this area.

The traverses of the United States in the Victoria Land plateau, together with preliminary reports of the British Trans-Antarctic Expedition and of other nations with bases in East Antarctica, give a general picture of this area. Westward from about 90° E, vast mountain ranges have been sighted and preliminary investigations conducted to indicate that these may extend 500 km inland from the coast.

South of the Australian Mawson Base, one of the largest known glaciers in Antarctica has been partially mapped. East of the 90° E, no large mountains have been found inland. Instead, traverses by the U.S., France and U.S.S.R. have all indicated that the land inland is generally very near if not below sea level for several hundred kilometers. Inland from this, the snow cover is quite thick, but the land is evident above sea level. Results of the Trans-Antarctic Expedition also show that land is generally above sea level along the route which includes the south pole. At the Pole of Inaccessibility Station of the U.S.S.R., located nearly in the center of East Antarctica, tentative reports give surface elevations of about 3700 meters, and ice thicknesses 2900 meters.

As noted previously, Antarctica is a drought area and average snowfall over the whole continent may be less than 40 cm per year, a 10 to 15 cm water equivalent. The available evidence points to a balance of incoming snow and outgoing losses. This evidence comes from various sources: lack of changes in elevations at coastal stations on shelf ice despite accumulation, identical locations of glacier fronts at present compared to times of Scott and Shackleton expeditions, and biological evidence. In a preliminary discussion of Antarctic plant life, Llano has concluded from ecological studies that the Hut Point area in McMurdo has been free of ice for well over 500 years, and that Taylor Dry Valley must have been ice-free for at least 1500 years. Similar inferences have been drawn from lichen locations on interior nunataks and exposed ranges.

It is still too early to evaluate knowledge of the movement of ice or changes of elevation in the interior. Changes of elevation with time will be studied by noting gravity changes over long periods of time at Byrd and Pole Stations. Early estimates from studies of the thermoluminescence of limestone rocks in the McMurdo area indicate that the continent has remained for at least 170,000 years without major temperature changes.

International—The international aspects of the IGY were very evident in Antarctic operations. Perhaps this is best illustrated on the Continent by United States and New Zealand. The Hallett Station was the sole jointly operating station in Antarctica, with U. S. and N. Z.

scientists alternating as station leaders. On the Ross Ice Shelf and Victoria Land traverses, and in special studies in the McMurdo area, New Zealanders joined U. S. operations and U. S. scientists joined the New Zealand groups.

At the International Antarctic Weather Central at Little America meteorologists of other nations were invited, and during the IGY period scientists from Argentina, Australia, France, New Zealand, Union of South Africa, and U.S.S.R. at one time or another participated. Two meteorologists from the U. S. Weather Bureau spent a year each at the U.S.S.R. Mirny base in a reciprocal agreement. Visits between bases of various nations were made whenever logistics would permit.

Perhaps most illustrative of the international cooperation on Antarctica and surrounding seas is the assistance given to other nationals. There are many examples of icebreakers rescuing ice-bound ships and aircraft flying to the rescue of stranded personnel; here nationality had no part.

The Special Committee on Antarctic Research (SCAR) was a natural outcome of the international coordination that characterized the IGY. The great effort spent and the large investment in station facilities and equipment could not be justified in the short period of IGY. Even before the official start of IGY, a recommendation was submitted to the Executive Board of the International Council of Scientific Unions (ICSU) for consideration of continued activity in Antarctica. An *ad hoc* committee met in Stockholm in September 1957, confirmed the need for further international organization for scientific studies in Antarctica, and recommended that ICSU select a committee to carry out the necessary action.

The first meeting of this SCAR Committee was held at The Hague February 3-5, 1958 with delegates from nine nations in addition to delegates of the International Unions of Geography, Biological Sciences, and Geodesy and Geophysics. A constitution was drafted, officers appointed, working groups formed, and a tentative plan for the scientific exploration of Antarctica in the years following IGY was prepared.

At the second meeting held in Moscow August 4-11, 1958, national reports on scientific research in Antarctica were summarized by the 12 nations, additional working groups formed, and dis-

cussions of the future of the Antarctic Weather Central initiated. Problems of communication within Antarctica, particularly the need for strengthening the southern hemisphere network were discussed. At this meeting also the problems of publications, and of Antarctic cartography were considered.

The third meeting of SCAR was held in Canberra in March 1959. Final problems arising from the establishment of the International Antarctic Analysis Center at Melbourne were resolved, advances made in the international aspects of cartography, and listings of scientific programs of all stations compiled.

The twelve nations presently members of SCAR by virtue of permanent bases on the Antarctic continent, or on islands within the Antarctic Convergence, are Argentina, Australia, Belgium, Chile, France, New Zealand, Norway, South Africa, United Kingdom, U. S., and U.S.S.R. A thirteenth nation is expected shortly when Poland takes over the Oasis Station from U.S.S.R.

Future plans—On the assumption of a lasting Antarctic program, the U. S. efforts were consolidated by limiting the working bases and increasing the scientific scope at the remaining stations. Under agreements with the respective governments, the operations at the U. S. stations at Wilkes and Ellsworth were transferred to Australia and Argentina, respectively, for administration, in both cases U. S. scientists remaining to effect a joint scientific program. The station at Little America was abandoned except for summer operations and activities of the Ross Sea area centered at the base at McMurdo, which had previously been a facility base only, except for special scientific work during the summer months. With this new consolidated plan of operation, more efficient logistic work is possible, and more attention can be given to outlying regions of Byrd Land such as the Horlick Mountains, the Amundsen and Bellinghausen Sea areas, and the mountains along the northern coasts.

A marked increase has occurred in the percentage of summer scientists in Antarctica since the beginning of the IGY. During the first season, the 75 wintering-over scientists represented nearly two-thirds of the total complement. During the coming season, the wintering-over scientists number about 35 with seasonal personnel

about double that number. This change has been possible with the increased air flights to Antarctica from New Zealand beginning early in October, and it has allowed investigations by more experienced scientists who would not otherwise be willing to spend the additional time in Antarctica.

With the ending of the IGY, sciences not previously included because they did not require synoptic observations, were added. In particular the operations now include studies in biology and the medical sciences, geology, and cartography.

Traversal operations will continue from the Byrd Station north to areas of the Amundsen and Bellinghausen Seas, and from McMurdo Sound to the high East Antarctica plateau region. The traversal work will be expanded to include more geological studies, and more cartographic work. Geological parties will also be located in strategic areas for special studies during the summer months.

Biological studies will be concentrated on the McMurdo Sound area, where the Antarctic Biological Research Laboratory is now installed, with the standard items essential for routine analysis and determinations. Microbiology, ecology and zoology are subjects at present having investigators in the field. Medical sciences of physiology and psychology are also being augmented.

The U. S. administration of the revised Antarctic scientific program has also been altered. The gigantic IGY program, funded by the National Science Foundation, was administered by National Academy of Science offices under Dr. Hugh Odishaw. At the close of the IGY period, with activities in the Antarctic continuing, the administrative work in this regional area was vested in the National Science Foundation, with the formation of the U. S. Antarctic Research Program offices under Dr. T. O. Jones. Here the programs are coordinated and problems of screening, briefing, and transportation of Antarctic scientists and their equipment arranged. Here also coordination is affected with Task Force 43, now under Admiral David M. Tyree. The National Academy of Sciences, through its Committee on Polar Research, has retained the expert advice and experience of the IGY in Antarctic work and outlines the broad long-range Antarctic scientific programs as guide

lines to the Foundation in its consideration of scientific proposals received from government agencies, universities, and outside groups. A parallel committee of interested government agencies, the Interdepartmental Committee on Antarctic Research, assists in the evaluation of future scientific programs.

Within a few years it is expected that programs of more complicity will be possible; such as land or ship-based rocketry for studies of upper atmosphere parameters, constant level balloons, long range cartographic programs and special Antarctic research ships for the more involved programs in physical oceanography, marine biology and submarine geology.

Logistically, the most promising assets in Antarctica are nuclear reactors for power (since a very high percentage of present cargo is fuel) and a land air strip for year around operation. With these two items, both of which are under consideration by the U. S. Navy, a new forward step will be taken in the still tremendous logistic task in Antarctica.

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The AMSOC Hole to the Earth's Mantle

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History of the project—It was July 1957 in Washington, D. C., when the Earth Sciences panel of the National Science Foundation (NSF) had just completed two days of hard work evaluating some 60 odd projects requesting research grants. The difficult job completed we relaxed to reflect on our work. Many of the suggested projects were excellent and most were of high calibre. Walter Munk remarked, however, that not a single one of them was of such a nature that a really major advance in Earth Science would result. He suggested the panel invent a project which might strike directly at the roots of a major problem and forthwith suggested a hole to the Moho. If the writer deserves any credit for past or future association with this project, it is that he took Munk seriously and prevented momentarily adjournment of the panel. In the few minutes remaining he proposed referring the project to the American Miscellaneous Society (AMSOC) for action. This was not a joke. It was done for several very good reasons.

AMSOC has no constitution, no officers, no members, only founders, many of whom are distinguished scientists. Here was a society which could act immediately—no need to wait for the next council meeting to have the proposal referred to a committee which would report to the council a year later. Gordon Lill was appointed chairman of the committee to proceed with the project and there followed the breakfast meeting in California mentioned by Bascom [1959] at which the specific plans were laid out. NSF being unable to grant funds to a society without officers or a membership list made it necessary that AMSOC get a reputable sponsor. The National Academy of Sciences—National Research Council very kindly, and, I might say, courageously, gave the AMSOC committee a respectable home. NSF funds for a feasibility study were then forthcoming and once in hand Bascom was appointed Executive

Secretary of the committee. The committee's history from this point on is one of record and can be left to historians.

I doubt whether Walter Munk was cognizant of Frank B. Estabrooke's note in *Science*, Oct. 12, 1956. But whether he was or not, Estabrooke should be given credit for inventing the same project for pretty much the same reason at an earlier date.

The meteorite analogy and the mantle—In 1850 Boisse proposed that the Earth's interior might be analogous in composition to meteorites. It was a brilliant proposal for its day and in a general way it is probably correct. In detail, perhaps, it is today being taken too seriously. It depends on how good the meteorite sample is, considering only those seen to fall, and how reliable a sample this is of the average composition of the body or bodies from which the meteorites were derived. The great majority of stony meteorites are analogous to volcanic rocks such as crystal tuffs, lithic tuffs, and breccias. Are we only getting a sample of the outer surface of the meteorite parent? Olivine nodules from the Earth's interior where ejected from a volcano as bombs are found to be friable, the crystals are loosely held together. This is probably due in part to sudden decompression and in part to the lack of a cementing matrix. The mantle of the meteorite parent body might well behave in a similar manner upon being suddenly extracted from its environment. Were this the case the small particles resulting would be swept up by the Sun leaving only the somewhat more lithified stony meteorites and irons in orbits which might collide with the Earth.

The decompressed densities of the inner planets (and the Moon) are not the same. This must mean that their compositions are not exactly the same. It may merely indicate a difference in the degree of oxidation of the iron present [see Ringwood, 1959, and many discussions by Urey]. It could mean that the initial bodies

forming the solar system varied somewhat in composition or that their initial compositions have been changed by some process which caused losses to surrounding space.

The uncertainties in the meteorite analogy cannot be resolved by further speculation. A hole or holes are required if we are to know something more definite about the chemistry of that 84% of the volume of the Earth called the mantle. (The crust is less than one per cent of the Earth and we know quite a lot about it from observation. It seems quite reasonable to accept the meteorite analogy to the degree of postulating a Ni-Fe core.) A half ton sample of mantle would probably give more specific information than the 1400 odd meteorites now in collections. The meteorites could then be properly evaluated to give much additional information. It seems foolhardy to put an enormous effort into attempts to sample the moon or even the planets without finding out what is five kilometers below the sea floor. The information from the hole is necessary to attack in a well-reasoned manner what we wish to find out about the moon. Compared to space exploration the cost is small.

Choice of site—Drilling a hole to the Moho in a continent is not at present possible because it involves depths near 100,000 ft and temperatures too high for modern drilling equipment. The high temperatures also present difficulties in that many desirable measurements could not be made because the electronic devices and electrical cables could not withstand such conditions. Oceanic islands were considered during the early stages of the feasibility study. Aside from the fact that these are of volcanic origin, and hence one would be drilling into the underpinnings of a volcano, the depth to be drilled would be too great. A small volcanic island rising from the ocean floor in depths of 15,000 to 18,000 ft would be about 40 miles wide at its base. Volcanic islands are in isostatic equilibrium. They represent loads in excess of the strength of the crust. If one assumes a density of 2.8 g/cc for the volcanic material this load would depress the Moho to 78,000 ft. Assuming the lowest reasonable density rather than the most probable one would give a depth in excess of 60,000 ft.

This leaves only one alternative, drilling a hole from a barge in the deep sea. The Moho

can in many places be reached at depths of 30,000 to 35,000 ft below sea level and only about half of this need be drilled, but the overlying water presents some unique problems. The ship must either be anchored or maintained in position by some sort of automatic position-keeping system.

In choosing a site the weather conditions must be considered. In general this led us to look for one at a latitude less than 25°. It must if possible be within 500 mi of a port where supplies and repairs can be obtained and exchange of personnel becomes feasible. The heat flow on the ocean floor must be less than two microcalories per cm² per sec. Assuming a conductivity of 0.005 cgs units, two microcalories gives a gradient of 40°C per km or 200°C approximately at the Moho which is somewhat too high for existing well logging instruments (Fig. 1).

Two areas seem to fulfill the above conditions. One is about 120 mi north of San Juan, Puerto Rico, and the other south of Los Angeles from Guadalupe Island towards Clipperton Island. Seismic work is now underway to find places in these areas where a depth to the Moho is favorable and where the heat flow is comparatively low.

Discussion of scientific objectives—Thus far the primary objective of the project, to sample the mantle, has been stressed. Lesser objectives

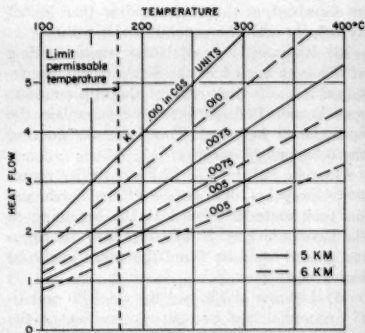


FIG. 1—Relationships between heat flow, conductivity and temperature at depths of 5 and 6 km below the ocean floor; heat flow given in microcalories per cm² per sec and conductivity in cgs units; temperature limit 180°C

of extraordinary interest and importance might be considered as by-products. An outline of the nature of the observations and measurements to be made will serve to clarify the objectives.

A. If an authentic sample of the material below the M discontinuity were obtained one could establish the following attributes for the following purposes:

(1) Density. The density of materials from the surface to the center of the Earth has been computed by Bullen and more recently by Bullard. These computations are based on the moment of rotational inertia of the Earth and are highly sensitive to the initial density assumed at the top of the mantle. If an exact figure could be given to this, the validity of the rest of the column would be greatly enhanced. The density values could also be used to great advantage in analyzing gravity anomalies in oceanic areas.

(2) Composition, bulk, and mineral phases. If the composition and mineralogy of the top of the mantle were known, a much more valid Earth model could be constructed. High-pressure and high-temperature research could be concentrated on the type of material found rather than on some hypothetical preference. The validity of the meteorite analogy as a model for the Earth's interior could be tested. The hypothesis of a high-pressure phase of basalt existing below the discontinuity could be proved or disproved, or the olivine nodule (peridotite) hypothesis could be similarly dealt with.

(3) Radioactivity. A better understanding of the heat budget of the Earth might be obtained if the radioactivity of the upper mantle were known. Perhaps some clue to explain the anomalously high heat flow from the floor of the ocean might result.

(4) Age. Possibly the M discontinuity represents the primordial surface of the Earth and the rock material formed at the beginning of the Earth's history. If some means of determining its age could be found the result might be highly significant.

(5) Isotopes of Pb, and the total Pb and U. If primordial, the isotopic composition of the Pb corrected for the radiogenic Pb from U and Th present would significantly enhance the understanding of all Pb isotope age work.

(6) After completing the hole, arrangements should be made to collect samples of gases or

liquids leaking into the hole from the mantle rocks. Some clues might be obtained from the amounts and composition of these fluids as to the rate and character of additions to the hydrosphere and atmosphere from the interior of the Earth, and the past history of this process.

B. What is the layer immediately above the M discontinuity with a seismic velocity near 6.6 km/sec? While it is generally said to be basalt, there is no evidence to substantiate this hypothesis other than that the velocity is appropriate. It would also be appropriate for a variety of other materials. What is the origin of this layer?

C. The sedimentary column from the sea floor to the material mentioned above could be sampled. Such a sample in the deep sea might give a complete sedimentary column stretching back to the beginning of the oceans. The fossil flora and fauna in this column back to the first appearance of life in the sea would be extremely interesting if it could be obtained. Or perhaps one would find that the oceans are relatively recent features on the Earth's surface. In any case here is a whole new world to explore. On the average, seismic information indicates about 1000 ft of unconsolidated sediment on the ocean floor. Layer 2 below this sediment has a seismic velocity ranging from 3.5 to 5.8 km/sec. This might consist of lithified sediments, volcanic rocks, or sedimentary rocks with igneous rock sills.

D. Overall properties of the materials through which the hole passed could be measured to great advantage.

(1) Thermal. One would like to obtain figures on the temperature gradient, conductivity, and a consequent better understanding of heat flow.

(2) Seismic velocity. A seismic velocity log could be obtained which would form a better basis to understand seismic results at sea and perhaps test for seismic anisotropy in different directions around the hole.

(3) Magnetism. The magnetic properties of the materials in the hole could be obtained. This would certainly lead to a much better means of interpreting the magnetic anomalies at sea. The direction and sign of the remnant magnetism of the rock samples progressively down the hole could be determined, perhaps shedding some light on paleomagnetic problems.

(4) Electrical properties. Various types of

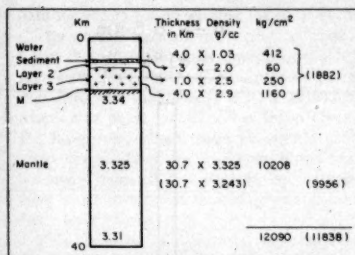


FIG. 2—Hypothetical crustal column where depth to the Moho is a minimum; Case 1 represents conditions on a gentle rise outside of a trench such as north of Puerto Rico where the column is slightly out of isostatic equilibrium (too high, small positive gravity anomaly); Case 2 (in parentheses) represents conditions where depth to the Moho is relatively small as a result of slightly lower than normal density in the mantle material

electric logging could be done coupled with the laboratory measurements on the samples.

Above are most of the obvious objectives but no doubt in probing into new and unexplored territory, the unexpected discoveries might play a large role in the final outcome.

Prediction and speculation—Before a deep hole is drilled the best estimate of what may be encountered must be made. The estimator takes the risk of being proven wrong.

Figure 2 shows a hypothetical column through an oceanic section. This is not an average column such as has been published elsewhere [Hess, 1955a] but one selected for comparatively shallow depth to the Moho. A section such as the one north of the Puerto Rico Trench might be expected to be somewhat out of isostatic equilibrium thus giving the observed small positive gravity anomaly and consequently a pressure of 12,090 kg/cm² at 40 km instead of the equilibrium pressure of 11,838 kg/cm² as estimated in Hess [1955a]. A similar situation might be expected on the gentle rise west of the Acapulco Trench in the Pacific. On the other hand the small depths to the Moho on the rise near Clipperton Island and northeastward probably are an isostatic-equilibrium situation with slightly lower density for the sub-Moho material, as is indicated in Figure 2 by

the quantities in parentheses. The actual thicknesses and layer velocities at a site chosen would be determined by seismic work and will then have to be specifically considered. The present example represents an average set of conditions for a favorable site as deduced by available seismic information.

The material of Layer 1, the unconsolidated sediments, is well known from cores obtained at sea and requires no further discussion. Layer 2 is very variable in thickness and in seismic velocity V_p , which ranges from about 3.5 to 6.0 km/sec. No doubt its make-up is variable too. Presumably it consists of consolidated sedimentary rocks or volcanic rocks or both.

The total thickness of Layers 1 and 2 is of the order of 1.3 km and if considered to be all sedimentary rock it is surprisingly small in amount considering present-day rates of sedimentation. Measurements made on cores of this commonly give a rate of about 1 cm/1000yr. A minimum rate seems to be about 1 mm/1000yr. If the oceans are postulated to be three billion years old, this would mean 30 km of sediment at the faster rate or 3 km at the slowest. The quaternary may be abnormal in its contribution of sediment to the sea because of Pleistocene glaciation, but this argument does not seem particularly convincing to account for a rate perhaps 50 times normal. The most obvious alternatives are: (1) The oceans are relatively young. At 1 cm/1000yrs the sediment could be accounted for if sedimentation only started in the Cretaceous. (2) The pre-Cretaceous sediments have in some manner been removed; for example, by incorporation into the continents by continental drift. (3) Non-deposition of any sediment over much of the ocean floor was a common attribute of the past. In any of these cases, those who expect a complete record far back to billions of years ago are doomed to disappointment. It will be extremely interesting when the well is drilled to find out which of these alternatives (if any) prove to be correct. In any case I would predict (though I am rooting against this prediction) that a very incomplete section will be found.

Layer 3 is commonly referred to as 'the crust' and is generally considered to be basalt. The reasons for calling it basalt are in part legendary, and in part based on its seismic velocity, which commonly ranges from 6.4 to 6.8 km/sec.

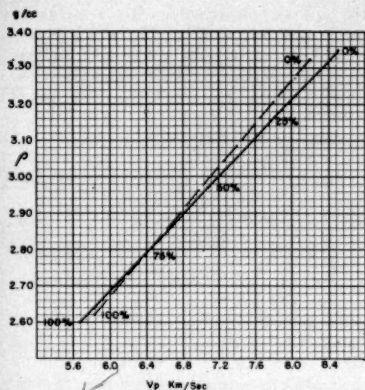


FIG. 3—Variation in velocity of V_p , density ρ , with percent serpentinization of peridotite; solid curve represents relationships for shallow depth and dashed curve an estimate of relationships at 15 km below sea level; curve based on laboratory measurements by J. Green at the California Research Laboratory, La Habra, except for sample of 100% serpentinized peridotite which was measured by Francis Birch at the Dunbar Laboratory, Harvard University; Birch's measurements were made at room temperature and pressures from 0 to 10 kilobars. Green's measurements were made with variable temperatures up to slightly more than 200°C and pressures up to one kilobar

Other than its seismic velocity there is no compelling reason for concluding it is basalt. It may be basalt or it may be serpentinized peridotite (Fig. 3). It could possibly be some other rock type. Serpentinized peridotite is favored by the writer because such material has been dredged from fault scarps on the Mid-Atlantic Ridge in three places by investigators from Lamont Geological Observatory [Shand, 1949]. Basalts have also been dredged from this Ridge but could be attributed to debris from nearby seamounts or volcanic islands. The unique thing about Layer 3 is its comparatively great uniformity in thickness. Figure 4 is a plot of frequency of occurrence of thicknesses for this layer. This is based on all of the published seismic profiles in the deep sea plus some unpublished data of Raitt but omits those profiles which appear to be complicated by seamounts or islands in the immediate vicinity. Note that

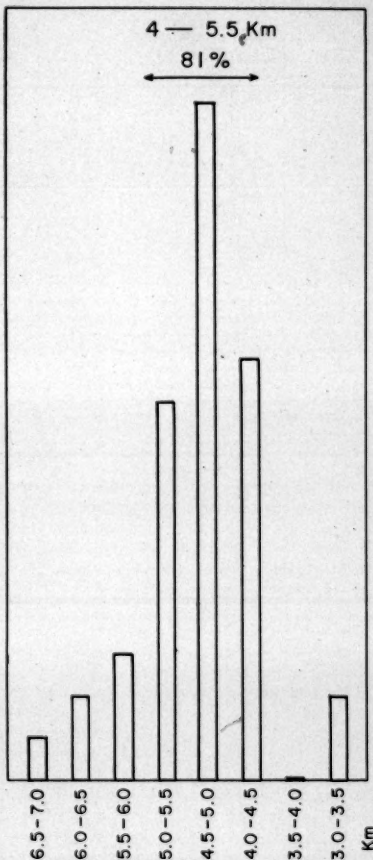


FIG. 4—Frequency histogram for thickness of Layer 3, the so-called 'basalt' layer

81% of the cases in the sample examined range in thickness from 4.0 to 5.5 km. This range necessarily includes observational error which reasonably could be considered to be ± 0.5 km. Raitt (personal communication) finds that the average thickness of Layer 3 for all of his profiles, and selected in much the same way as the

data for Figure 4 were selected, comes to 4¾ km.

The surprising uniformity in thickness of Layer 3 requires that the bottom of the layer represent the position of an isotherm or past isotherm, and that this is a level at which a reaction or phase transition has taken place. If the layer were basalt flows one would expect great variability in the thickness. Flows would be many times thicker near a vent or fissure from which they issued than at greater distances from their source.

This leaves two alternatives: (1) that Layer 3 is basalt but that rocks of this chemical composition extend down into the mantle and are converted to eclogite (this was originally suggested by Sumner [1954] and also later by Kennedy [1956] and others), or (2) that the 'crust' and material below are peridotitic in composition and an abrupt change from partially serpentinized peridotite to unserpentinized peridotite occurs at the Moho. The latter case would be consistent with Ringwood's [1958] model for the mantle and the writer's [Hess, 1955b]. In this case the Moho under the oceans would represent some ancient time when the 500°C isotherm stood at this datum plane below sea level. A glance at Figure 1 shows that it must be very much deeper than this today.

Summary of predictions:

(1) Layer 1 consists of unconsolidated sediments.

(2) Layer 2 consists of consolidated sedimentary rocks with or without volcanics.

(3) The so-called 'basalt,' Layer 3, is serpentinized peridotite such as has been dredged from the Mid-Atlantic Ridge.

(4) The mantle will be peridotitic and the same composition as the olivine nodules of Ross and others [1954] and in Hess [1955b] and also the same composition as St. Paul's

rock. Ringwood's model will be substantially correct.

(5) The sedimentary-rock section of Layers 1 and 2 will be very incompetent.

Conclusion—Geophysicists and geologists dealing with the solid Earth have tended to be conservative in their objectives. Excellent though their projects may have been, no one or group of them could possibly break through to completely new ground. Let us "take the bull by the horns" and find out what this planet upon which we reside is really made of instead of relying on ethereal analogies. This is a courageous project which deserves support. Besides this it fits Revelle's classic definition of good research, it will be fun to carry out.

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Water-Level Fluctuations Caused by Montana Earthquake

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The major earthquake of August 17, 1959, near the Montana-Wyoming border had marked effects on water levels and artesian pressures in wells throughout the United States.

Preliminary reports from field offices of the U. S. Geological Survey in 21 states show that water-level fluctuations were automatically recorded in 136 observation wells. These wells for which records are available, and the maximum double amplitude of the fluctuations, are listed in Table 1.

According to the U. S. Coast and Geodetic Survey, the quake was followed by four major aftershocks on August 17 and four others on

August 18. Fluctuations produced by the aftershocks also were recorded in some areas.

The maximum fluctuation reported was recorded in an artesian well, 304 feet deep, in Idaho, about 85 miles south of Hebgen Dam the approximate epicenter of the earthquake; the double amplitude of the fluctuation exceeded ten feet.

Wells in Hawaii, more than 3200 miles from the epicenter, registered fluctuations up to 0.10 foot and a fluctuation of 0.01 foot was recorded in a well in Puerto Rico.

Of particular interest are the fluctuations registered in the water level of three mine-water pools in the northern anthracite field in northeastern Pennsylvania, ten miles north of Wilkes-Barre. The double amplitude of the fluctuations ranged from 0.05 to 0.17 foot.

Studies of seismic fluctuations of water levels indicate that they are caused mainly by Rayleigh waves. Records of these fluctuations are summarized annually by the U. S. Geological Survey and published by the U. S. Coast and Geodetic Survey in *U. S. Earthquakes*.

Studies of the effects of earthquakes on water levels in wells have great potential scientific value. The interest in these studies is in attempting to determine from these data the elastic properties of artesian aquifers which are an important factor in the development of ground-water supplies. The Geological Survey is developing instruments that will use a highly sensitive pressure transducer connected electronically to a tape recorder, to measure the amplitude and period of the fluctuations more precisely than can be recorded with the instruments now in use. Moreover, by simultaneous recording of time signals it is expected to obtain the time of the fluctuations very accurately.

TABLE 1—Summary of effects of Montana earthquake on water levels in observation wells (Preliminary data)

State	Number of wells	Maximum amplitude ft
Alabama	8	1.3
Arizona	3	.29
California	22	1.07
Colorado	1	.03
Florida	15	.48
Hawaii	4	.10+
Idaho	18	10.0
Indiana	10	.49
Kentucky	2	.28
Michigan	5	.26
Minnesota	6	.67
Montana	10	1.76
Nebraska	1	.23
Nevada	3	1.00
New Jersey	6	0.72
New York	2	.28
Oklahoma	1	.28
Puerto Rico	1	0.01
Texas	4	.60
Utah	5	5.1
Washington	6	1.15
Wisconsin	4	1.00+

International Geophysics Committee

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The CIG, to use the authorized initials after the French name, Comité International de Géophysique, held its initial and organizing session at The Hague, November 4-6, 1959. Established by the International Council of Scientific Unions (ICSU) in conjunction with four unions (IUGG, IAU, URSI, and IUPAP), the new committee is charged with "adequately terminating the work of the IGY and IGC-1959" and with responsibilities relating to "continued international and inter-disciplinary scientific co-operation in the fields of geophysics and related sciences."

At its first meeting the CIG considered the charter of its functions, composition, and procedures as drafted by the ICSU Executive Board on the basis of suggestions by CSAGI and others. It examined the question of bringing to completion the IGY and IGC-59 endeavors, and then turned its attention to the future. Recommendations in the latter area, as well as the prospect that CIG provides a means for further international and interdisciplinary collaboration along the lines of the IGY, are perhaps of immediate interest to the scientific community. In effect, it is the successor body to ICSU's special committee for the International Geophysical Year—the CSAGI, which terminated on June 30, 1959.

Sir Rudolph Peters, President of ICSU, in welcoming the members of CIG on the morning of November 4, dwelt briefly upon the background which afforded the CIG its points of departure, noted its principal tasks, and expressed his hopes for the Committee's achievement of its objectives. The CIG Secretary, G. Laclavère, outlined the IGY background of CIG by way of preamble to a consideration of the charter.

Even before the IGY had formally terminated, its operational success had led scientists convened at the Fifth General Assembly of the CSAGI (Moscow, July 30-August 9, 1958) to

propose its extension for a one-year period. This extension, called International Geophysical Co-operation-1959 (IGC-59), entailed (1) the conduct of world-wide coordinated geophysical studies as in the IGY but at levels congenial to participants, and (2) the continuance of data interchange through the three IGY World Data Centers. IGC-59, unanimously endorsed at the Moscow CSAGI Assembly, was confirmed by the Eighth General Assembly of ICSU, October 2-6, 1958, Washington. The task for coordination was assigned to the CSAGI with provisions for the establishment of a successor committee during 1959.

The nature and responsibilities of the proposed new committee were considered by various bodies during the ensuing year—for example, by the ICSU Bureau in April 1959, the CSAGI in May, the URSI Board of Officers in June, and the IUGG Executive Committee in September 1959. These considerations, along with suggestions of scientific institutions adhering to ICSU, were presented to the ICSU Executive Board, September 30-October 3, 1959 and led to the establishment of CIG, the issuance of draft rules, and selection of membership. The presidents of ICSU, IUGG, IAU, URSI, and IUPAP jointly determined the following composition of CIG, taking into account nominations by designated Unions and groups in the ICSU structure.

Bureau members: President, V. V. Belousov (USSR) (IUGG); three Vice Presidents, Edward Appleton (UK) (URSI), John R. Winckler (USA) (IUPAP), and M. Minnaert (Netherlands) (IAU); Secretary, G. Laclavère (France) (IUGG).

Other members: meteorology, J. van Mieghem (Belgium); nuclear radiation, B. Bolin (Sweden); aeronomy, M. Nicolet (Belgium); geomagnetism, V. Laurson (Denmark); aurora and airglow, C. T. Elvey (USA); solar activity, M. A. Ellison (Ireland); ionosphere, W. J. G.

Beynon (UK); cosmic rays, S. N. Vernov (USSR); oceanography, V. G. Kort (USSR); glaciology, G. de Q. Robin (Australia); seismology, F. Press (USA); and paleogeophysics, T. Nagata (Japan). In accordance with the charter, representatives of World Data Centers A and B, Hugh Odishaw (USA) and P. K. Evseev (USSR), became members upon designation by their academies, and the representative of the World Meteorological Organization was J. van Mieghem.

The draft rules were further polished by the CIG at its meeting along lines considered to be consistent with the intent of the ICSU Executive Board, and the quotations in this article are from this latest text.

IGY-IGC recommendations—The objectives of the CIG, as defined in paragraph 2 of the charter, are two-fold. "First, to ensure the fullest possible exploitation of the IGY and IGC-59 data, including: maintaining the efficient functioning of the WDC's, encouraging the discussion and utilization of IGY and IGC-59 results, and publishing the IGY and IGC-59 results and bibliographies. Second, to develop and coordinate international plans for the furtherance of cooperation in geophysics and related sciences, especially those of an interdisciplinary nature, including: the assembly and intercomparison of national programmes, the development of international data interchange arrangements and the continued utilization of WDC's; and to encourage appropriate discussion and publication of the results of such programmes."

Accordingly, the CIG considered that its first and most urgent task was the completion of the IGY and IGC-59 efforts. To this end, publication of the *Annals* was deemed most important, and the CSAGI Reporters for the IGY disciplines were co-opted to serve on CIG for this part of the work, in accordance with prior CSAGI resolutions. The CSAGI Reporters, who were the vital scientific core of the IGY, have in effect been serving as a board of editors for the *Annals*, each responsible for his discipline. Their task is to compile, prepare for publication, and edit the results of the IGY-IGC, largely embracing (1) data processed in various forms, and (2) summary reports.

Related to publication of the *Annals* are completion of IGY-IGC data interchange and the issuance of data-center catalogues. The CIG

urged participating IGY committees to complete IGY data interchange and to expedite IGC data flow, authorizing the Secretary to monitor this activity. The CIG also requested continuation of the cumulative six-month catalogues through December 31, 1960 and called upon the WDC's to prepare, issue, and distribute catalogues as in the past. The Secretary was asked to review this activity on behalf of CIG and to prepare and distribute cumulative six-month catalogues embracing all disciplines. Provisions were also made for the publication of these catalogues in the *Annals*.

The future—Even though an appreciable body of literature is already in being, analyzing and interpreting IGY and IGC observations, the extent of this unprecedented corpus of data represents an immediate and compelling challenge to geophysics. The need for and value of analytical and theoretical studies, frequently the subjects of discussion among scientists during the final months of the IGY, were re-emphasized, and the CIG called upon adhering scientific institutions to encourage and intensify this work during the next two years. So significant did the CIG deem this activity that it formally characterized the two-year interval January 1, 1960 to December 31, 1961 as the "IGY-IGC analysis and theoretical research period." It was stressed that research papers should be published in the customary scientific journals.

The CIG then addressed itself to the problem of what if any further activities merited conduct under an international aegis. Here, first of all, the activities of IGC during 1959 were cited as exemplary, for these observational efforts represented at most only an incremental effort over and above studies that would have been undertaken in various countries in any event. Yet these efforts, as formalized in a simple manner under IGC-59, permitted a desirable continuity of international discourse in geophysics and, above all, the sustained interchange of data through an existing mechanism. Therefore, the CIG called for a similar effort during 1960 and 1961, to be made tangible by two actions of adhering scientific bodies: first, submission of program documents, which would serve to inform all participants of the nature and scope of national contributions and, second, an interchange of observational data through the World Data Centers.

Both IGY and IGC-59 called for extensive interchange of raw data, particularly in the synoptic areas—meteorology, ionospheric physics, aurora, airglow, geomagnetism, and solar activity. Having accumulated essentially complete bodies of such data during the 1957-59 period, which coincided with sunspot maximum and was characterized by historically unprecedented solar activity, geophysicists must consider anew the nature and form of data to be interchanged in the future. The fact that relative thoroughness of exchange marked IGY-IGC data flow and that such completeness was justified scientifically provides no *a priori* foundation for projecting identical requirements in the years ahead. Accordingly, the CIG recommended a critical and periodic review of this matter. More specifically, the discipline members of CIG and the CSAGI Reporters were asked to examine "the needs and interests of science with respect to future interchange in consultation with relevant Union organizations and to recommend to the CIG, discipline by discipline, the exact nature and form of future (post-1959) data interchange." This is thus a subject that requires thought upon the part of the various specialists in the fields of geophysics.

The uninterrupted operation of the World Data Centers, however, was deemed necessary, in part because they afford a natural and existing medium of data collection and in part because they already represent an invaluable depository for the research worker. Many decades will pass before the riches of these reservoirs shall have been exhausted, providing as they do a unique opportunity to correlate data in many fields. Special note was taken of U. S. and U.S.S.R. intentions to continue their centers and of Japanese plans to extend their several discipline centers to embrace all disciplines involving the upper atmosphere.

Aside from providing a basis for international continuity in what might be called 'normal' geophysical studies as suggested above, the CIG entertained the notion of special endeavors that might be undertaken. In this connection, special notice was taken of the World Magnetic Survey to be made during a quiet interval in the solar cycle, initially proposed early in the planning for IGY by Professor Sydney Chapman and recently under intensive study, particularly by the IUGG International Association of Geomag-

netism and Aeronomy. The CIG not only endorsed the Survey but suggested that "adjoint programmes in the fields of upper atmosphere research should be considered" for this same period, a few years hence.

The CIG concluded its consideration of this broad subject—future special efforts—with an invitation for assistance from its discipline members, the sponsoring unions, and adhering academies. Clearly, such special efforts must evolve out of needs of the various disciplines, and it is expected that specialists will be the source of such proposals as are important to the interests of geophysics and related sciences.

The proposed two-year observational period of 1960-61, the ensuing pattern of data interchange, the World Magnetic Survey and possibly related studies during sunspot minimum, proposals for additional major researches in years ahead: all of these topics will be discussed at one time or another during the next year or two. The General Assemblies of the IUGG and URSI and associated international symposia afford splendid opportunities for colloquies among specialists. Yet some of these topics call for prompt consideration, for planning and organizing of the simplest type, whether nationally or internationally, takes time. Thus, the CIG will meet again late in March or early April of 1960 while a meeting of the World Data Centers and the ICSU Permanent Services is tentatively scheduled for May 1960. National programs for 1960-1961 will be discussed and arrangements for data interchange outlined.

Organisational aspects—The specific composition of CIG has already been presented. How it will cope with the many aspects of geophysics is suggested by detailed provisions in the draft rules. Quite aside from the two categories of objectives quoted earlier, the general character of CIG is indicated in the following and opening charter provision: "The International Council of Scientific Unions, considering the great achievement of the IGY enterprise, the necessity of adequately terminating the work of the IGY and IGC-1959, and the merits of continued international and interdisciplinary scientific cooperation in the fields of geophysics and related sciences, decides to establish an inter-union committee (to be known by the short title of International Geophysics Committee—Comité International de Géophysique (CIG)), to effect such

cooperation, and delegates to the IUGG the authority to administer the Committee on behalf of ICSU, in consultation with, and with the participation of the following Unions: International Union of Geodesy and Geophysics, International Astronomical Union, Union Radio Scientifique Internationale, and International Union of Pure and Applied Physics."

Just as the scientific strength of the IGY rested heavily upon the CSAGI Reporters, the burden of CIG programmatic responsibilities falls upon the discipline members. It is expected that the Unions will provide support to these individuals through their specialized groups, broadening the base of suggestions and recommendations presented by the discipline members. Close relationships between CIG and special committees are also necessary. In particular, provisions are included for appropriate liaison with the following three ICSU committees: COSPAR, which has cognizance over rocket and space science; SCAR, which is responsible for Antarctic activities; and SCOR, which is concerned with all aspects of oceanic and marine sciences. Similar ties exist with the International World Days Service, which will continue the World Days program that proved so valuable during the IGY.

Orderly provisions for handling fiscal matters, agenda and minutes, and reports are contained in the charter. The initial budget proposed by CIG for the coming year amounts to \$43,500. Of this, \$39,500 is needed in connection with preparation and publication of IGY-IGC results in the *Annals*. The balance available from ICSU's funds for the central IGY organization has not been finally determined, but such funds will be devoted to the publication program. Quite likely some additional funds must be obtained: the Royal Society has already provided \$7000 to assist in publications while very recently a subvention of \$10,000 was made by UNESCO.

National participation in the activities of the CIG is recognized as a responsibility of the scientific organizations adhering to ICSU. Our own National Academy of Sciences must accordingly determine the appropriate mechanism for its cooperation with the CIG. Discussions during the last year suggest that the variety of interests in the United States calls for an approach that gathers together the interests and competences of the four U. S. National Committees, which serve as domestic counterparts to the IUGG, IAU, URSI, and IUPAP, together perhaps with representation of several specialized Academy committees. The Executive Committee of the AGU, at its meeting on November 14, 1959, endorsed in principle an approach of the above kind and indicated its intent to participate vigorously in the actions of such a body.

The first session of the International Geophysics Committee proved to be a rewarding and constructive one. The new Committee, acting harmoniously and in complete unanimity, took several significant initial steps, both toward completion of IGY-IGC and with a look to the future. The remarkable background of the IGY afforded a satisfying point of departure for the CIG, which now provides scientists with an opportunity to continue international cooperation in those fields of geophysics and related sciences that are of compelling interest to science and to mankind. The election of Professor Sydney Chapman as Honorary President of CIG, an action inherently meet and felicitous, symbolizes the continuity of these endeavors in exploring man's physical environment. What CIG may undertake and what it may achieve now rest upon the decisions and efforts of geophysicists themselves. To paraphrase an opening remark of Sir Rudolph Peters: the CIG is here to make things easier for scientists to do their work.

Reviews

DAVID KEITH TODD, *Ground Water Hydrology*, John Wiley and Sons, 336 pp., 1959, \$10.75.

Professor Todd has set himself the task of presenting the fundamentals of ground-water hydrology as concisely and briefly as possible. The book is aimed at students and professional men engaged in a variety of fields of endeavor directly or indirectly involved with water and its works, including engineering, geology, agriculture, and water supply. It comes at a particularly appropriate time. The last comprehensive English-language text on the subject was C. F. Tolman's work entitled *Ground Water*, which appeared in 1937. In the meantime, the rapidly increasing demand for water has stimulated development of ground-water resources which has, in turn, magnified existing ground-water problems and added new ones for which solutions must be sought. Methods of investigation have been improved, better means of extracting ground water have been developed, conservation principles have been established, and several lines of research have clarified our understanding of the subject.

The first six chapters of the book cover the basic quantitative aspects of ground water — use, occurrence, movement, hydraulics of wells, construction and development of wells, and water-level fluctuations. Succeeding chapters discuss quality of ground water, basinwide ground-water development, surface and subsurface methods of investigation, artificial recharge, and intrusion of aquifers by sea water. A chapter on the legal aspects of ground water provides an enlightening discussion of the factors involved in the legal controls over ground-water withdrawals in various sections of the United States. The final chapter discusses recent developments in the study of ground water and its movement by means of models and by statistical analysis of ground-water data.

This book is interestingly written and is illustrated with a great many line drawings which aid materially in the understanding of the principles set forth. At the end of each chapter is an extensive list of references to the principal authorities for statements contained in that chapter. This should provide the student who desires further information an excellent starting point for further study. Illustrative examples based on field studies are kept to a minimum because of their ready availability in the published literature.

A possible weakness in the book for the general user is that the principal emphasis is placed on the development of large water supplies from sand and gravel aquifers, whereas there is relatively little discussion of the development of ground water from calcareous and volcanic rocks, which produce large supplies in many areas and which

are the sources of most of our first-magnitude springs. The crystalline rocks, which in many sections of the country provide small towns and farmsteads with their principal source of water, likewise receive scant attention. Nevertheless, the book fulfills a longstanding need and will be a valuable addition to the libraries of those interested in ground water and its development.

A. Nelson Sayre

H. BENIOFF, M. EWING, B. F. HOWELL, JR., AND F. PRESS (eds.) *Contributions in Geophysics in Honor of Beno Gutenberg*, Pergamon Press, 244 pp., \$9.00.

It is only fitting that a group of eminent authors, who are at the same time conferees of Dr. Beno Gutenberg, join in the preparation of a volume entitled *Contributions in Geophysics with the subtitle in Honor of Beno Gutenberg*. The book is edited by Drs. H. Benioff, M. Ewing, B. F. Howell, Jr., and F. Press, and consists of 17 articles.

The charm and value of the volume are perhaps attributed best to its mood. The authors, in almost every case, seem somewhat more relaxed in writing this memorial volume than appears to be the case when they are writing for the technical journals. This gives a degree of warmth to their expression and to their ideas which is gratifying. The subject matter is essentially seismic, which is not surprising in view of Dr. Gutenberg's emphasis on that geophysical science. Most of these seismic articles concern fundamental questions of energies and mechanics of earthquakes, travel times, and the resultant ideas concerning the structure of the Earth. Five articles are of a non-seismic nature, one of which is gravity, one is perhaps magnetic, one concerns data processing, and two are concerned with what might be called the behavior of the Earth. Brief comments on each of the articles will provide a factual review of the contents of the book, so these follow.

Markus Bath writes the first chapter on "The Energies of Seismic Body Waves and Surface Waves." The gist of this article is that body waves should not be used for the determination of absolute values of energies as a consequence of the extinction of these waves primarily due to their scattering within the crust. On the other hand, he demonstrates that more reliable values can be obtained from surface waves, and he concludes with an energy formula of $\log E = 12.24 + 1.44 M$, where M , is calculated from the amplitudes of surface waves for shallow, distant earthquakes.

Byerley and DeNoyer continue the examination of earthquake energies but by computing them

from geodetic observations relative to displacements occasioned by three western United States earthquakes of 1906, 1940, and 1954. Their method is "to compute the shear-strain energy (about to be relieved) in the Earth just before the faulting, or its equivalent, the work done at the time of faulting." The three earthquakes, 1906, 1940, and 1954, give approximate values of 0.9, 0.01, and 0.1×10^{23} ergs, respectively.

Wilhelm Hiller shows the geographic distribution of major earthquakes. In the second section he describes the mechanics of the earthquake shocks, themselves, in the vicinity of their origin. In the third and following point he couples these two phenomena, the geographical distribution and the mechanics of the shocks, in an attempt to show that this relationship is diagnostic of the entire dynamical question of earthquakes.

Robert Stoneley discusses "The Variation of Amplitude in Love Waves" in the short Chapter 3. Of interest is his conclusion that most of the energy of relatively short waves is confined to the granitic layer but that most of the energy from long waves is in ultrabasic material with the remaining energy divided about equally between the superjacent surface layers of basalt and granite.

Caloi discusses the relationship between slow movements of the crust and shocks in an area of high seismicity by observing tilt variations in connection with earthquakes in the Trieste area. Slow movements and preceding shocks are in the same discussion as the initial movement of the longitudinal wave of the following shock. Tilt meter records also show movements associated with both distant and near earthquakes.

Francis Birch discusses the "Interpretation of the Seismic Structure of the Crust in the Light of Experimental Studies of Wave Velocities in Rocks." Experimental data on velocities in granites and gabbros tend to confirm that the velocity distribution should be one of gradual increase with depth and that this can be easily accounted for in terms of "an increasing gabbroic component." This therefore casts doubt upon the existence of low velocity layers. The article is particularly pertinent to the rather conflicting patterns of vertical velocity distribution which emanate from various authors and from various areas.

Tatel and Tuve have been studying crustal structure, principally its thickness, for many years by means of seismic observations from explosives. They tried to get away from noise around the pickup by placing seismometers at depths of 3000 ft in abandoned gas wells in western Pennsylvania in order to try and receive reflections from the base of the crust. Although the ground motion was considerably less than the surface motion at this depth, no reflections were obtained from the lower crustal boundary.

In "Seismic Activities in and near Japan," Tsuboi finds that the relationship between magnitudes and distances from epicenters may be fixed for restricted areas, "earthquake provinces," while

variable amongst these areas. Probably these areas represent large tectonic structures. He takes issue with given expressions for the "mean annual number of earthquakes" because they are unrepresentative of Japan and because they do not permit superposition of area upon area when log N is a linear function of the magnitude. On the other hand, he tackles the problem of total earthquake energy from volume consideration and finds excellent confirmation of the "new" (1956) Gutenberg-Richter formula, $\log E = 11.8 + 1.5 M$. Tsuboi is quite concerned with distribution of seismicity and has good evidence to show that district earthquake provinces in Japan are about 150 km wide.

John H. Hodgson has previously written that earthquakes associated with particular geographic features "have null vectors which lie parallel to these features. Later, McIntyre and Christie said that this demands, rather obviously one would think, that "the fault strikes be parallel to the feature" or that "the displacement be perpendicular to the feature." From Western Pacific earthquakes, Hodgson finds evidence to favor the latter condition.

Miss Lehmann discusses travel times at epicentral distances between 105° and 115° . She finds substantially that tables of travel times are somewhat inadequate, probably because of variations in the earth's composition and structure.

K. E. Bullen summarizes good evidence for the existence of a solid inner core of the Earth overlain by a fluid outer core, in turn overlain by the mantle. Substantiation of this existence should be found in the detection of S waves through the inner core, a delicate task, and in theoretical physics.

Rothe discusses the structure of the crust in western Europe from seismic studies. In the Black Forest, Rothe and Peterschmitt put the Mohorovicic discontinuity at an interface between gabbro and peridotite with a corresponding velocity change of 6.54 to 8.15 km per second at a depth of 30.2 km. The Conrad discontinuity between granite and gabbro is placed at approximately 20 km where the velocity changes from 5.97 to 6.54. A high velocity of 6.0 is identified at the very shallow depth of approximately 2000 m west of Marseilles and south of Arles. It is difficult to identify this geologically because of the absence of deep drill holes, but it is known that in nearby Vaucluse to the northwest, a velocity of 5.0 at 1500 m depth can be identified with the calcareous rocks of the Upper Jurassic. Also of interest is the easy identification of Rayleigh waves which have velocity of 0.5. These waves are thought to occur in alluvial materials. Rothe discusses the results of Reich, who got reflections from the basal crustal discontinuity in 1952 from detonations in the sea and in caves near Blaubeuren at 7.075 and 9.20 sec which give depths of 20.3 km, 27.6 km, using velocities of 5.75 and 6.0, respectively. These results are the same magnitude of depth as those found with refraction from the 73 ton explosion

in the Black Forest. Also, the Conrad discontinuity is confirmed by the Blaubeuren observations. A long event at 10.08 sec is likewise identified east of Paris. Here, a velocity of 7.0 is needed to put the crustal discontinuity at 30 km.

Pekeris and Jarosch find support for Benioff's period of 57 minutes for free oscillations of the spheroidal type for the Earth. Radial type oscillations appear to have a first modal period of about 21 minutes. These results are from systematic studies of "average" and "real" Earths by exact, numerical, integration, and variational methods. The Weizac computer is being used for additional exact solutions, but so far it would appear that "the existence of the liquid core as well as the effect of the boundary conditions at the surface, where the rigidity is smaller than average, tend to make the real earth behave dynamically in spheroidal vibrations as a less rigid body than is represented by the mass-average value of the rigidity."

F. A. Vening Meinesz writes on the "Geophysical History of a Geosyncline," the area in question being that of the western part of the Alps. Basically, the developmental history is bracketed within three stages where, in the first stage, there is a simple subsidence of the crust with a concomitant folding of surface layers. In its second stage there is "a rising leading to a mountain range." In the last stage, a lowering of the area results from "subsidence and erosion accompanied by the development of low topographic features in the foreland." Emphasis is placed upon the "episodic occurrences" of the entire phenomena of the three stages as opposed to a "periodic occurrence." The application of this to the western Alps is considered to correlate well with the geological evidence.

An interesting and very up-to-date chapter is written by H. E. Landsberg on "Data Processing in Geophysics." He first recognizes that geophysics is one area in which computing aids were first employed, then he traces the development through modern electronic computers. Of great interest are his prognostications of progress still to be made in the areas of developing the output of sensing and measuring devices for automatic transformation as input into computers, the establishment of a "central library of basic computer programs," and the use of automatic equipment for printing results in order to prepare material for extremely prompt publication.

Heiskanen and Uotila write Chapter 15 on the gravity formulas of the Earth. They list the changes in the formula leading up to the one adopted in Stockholm in 1930 as the "International Gravity Formula." They then proceed to discuss the areas devoid of gravity measurements; the Pacific is the emptiest. Another relative area of large size is in the Atlantic between latitudes of 60° and 20°W.

"Geomagnetic Drift and Rotation of the Earth" is not the broad treatment of the subject that the title might imply. Elsasser and Munk show mathe-

matically that "excursions of the pole based on variable coupling with the core are negligible." They note that they "are not ruling out the possibility of polar wandering, but are here dealing exclusively with the possible effect of the dynamics of the core upon the solid mantle and crust."

Nelson C. Steenland

CHARLES F. RICHTER, *Elementary Seismology*, W. H. Freeman and Co., San Francisco, viii + 768 pp., 47 tables, 205 figs., 1958, \$12.00.

As the author explains in his preface, this elementary treatise is written for geologists. The author, with physics as his background, has undertaken the rather difficult task of preparing a book on seismology without the use of mathematics. Considering the highly mathematical nature of a large part of seismology, the author has succeeded remarkably well. To be sure, a large part of the most interesting areas in seismology have necessarily had to be omitted, but the geologist will find much material which will interest him. There is much descriptive matter relative to earthquakes in general, and a large part of the book consists of detailed descriptions of a number of severe earthquakes which have occurred in the past. The book contains some exciting photographs of recent faults which have initiated earthquake tremors. Also, there are a large number of photographs of earthquake damage to buildings of various types of construction. Maps taken from the book *Seismicity of the Earth* are reproduced here, showing the distribution of epicenters over the Earth. There are numerous photographs of earthquake seismograms and drawings showing the paths of seismic waves through the Earth as they reveal the nature of the Earth's deep structure.

Some small amount of mathematics has been put in appendices in the back of the book in order, in a small measure, to offset the lack of it throughout the text. This mathematics, however, is not essential to an understanding of the text, and is included only for the benefit of those who may wish to refer to it. A slight amount of mathematics is included in Chapter 15 as being unavoidable in explaining the operation of the seismograph as an instrument. The mathematics, however, is rather elementary and has been used so much in the treatment of resonant devices that it has become inseparable from the seismograph. Indeed, if the geologist intends to understand the operation of the seismograph at all he most certainly had better make a point of becoming acquainted with it.

The book closes with some tables of travel time as a function of distance over the Earth's surface with depth of focus as a parameter, a brief chronological history of seismology, selected bibliographic references, and some additional tables. It should be added that each chapter of the book

is followed with adequate bibliographic references relating to the chapter.

Norman H. Ricker

C. H. B. PRIESTLEY, *Turbulent Transfer in the Lower Atmosphere*, University of Chicago Press, Chicago 37, viii + 130 pp; 22 figs., 10 tables, 1959, \$3.75.

As recent progress in the study of the atmospheric boundary layer is very rapid, it is a difficult task for newcomers to this field or research workers in various other fields of meteorology to keep abreast. Nevertheless, the importance of turbulent transfer of various quantities has been increasingly recognized in atmospheric general circulation research, numerical weather prediction, and cloud-physics research. Under these circumstances the publication of this stimulating book should be greatly appreciated by research workers in the various other fields of meteorology as well as those who specialize in this field. This handsomely produced book presents many recent contributions heretofore scattered in various technical reports and journals, and thus allows one to review the recent progress. Many suggestions helpful for further developments in the study of turbulent transport are presented.

The author presumes a basic knowledge of micrometeorology such as that obtainable in the textbook of O. G. Sutton, and mostly concentrates on topics which have appeared since the completion of that book. This concentration on recent progress seems to lend this book an atmosphere of vividness and urgency. In his preface, Priestley said that he attempted to supplement the Sutton textbook. To a certain degree, it is so. However, this is not the kind of book which uniformly covers the various problems of micrometeorology. Rather, the merit of this book is that we can get his unique opinion and critical, penetrative ideas about observational material and recent theoretical work.

A brief review of the contents of each chapter might be useful. In the second chapter, following the Introduction, discussion is centered on the measurement of the vertical eddy flux of heat, momentum and moisture, which constitutes the basis of developments in later chapters. The difference of mechanism between heat and momentum transport in an unstable atmosphere is emphasized. In the third chapter an analysis of the wind profile and the vertical eddy transport of momentum under various stability conditions are discussed. Deacon's elaborate analysis and the fundamental and ingenious framework of analysis proposed by Monin and Obukhov are critically reviewed. Also the problem of roughness measurement on the ocean surface and that of the approach with height of surface wind to the geostrophic wind are discussed. In the fourth, fifth, and sixth chapters, the problem of free and forced convection is studied from both observational and theoretical viewpoints. In Chapter 5 the careful

analysis of observational data which exhibit the plume-like structure of free convection and the difference between this structure and that of forced convection, leaves the reviewer with a very favorable impression. The problem of free and forced convection is one of the most difficult and debatable in the field of micrometeorology, and one which has been most extensively investigated by the Staff of the Division of Meteorological Physics, Commonwealth Scientific and Industrial Research Organization, Australia. These chapters are arranged in such a way as to give us a coherent as well as a comprehensive picture of convection.

In Chapter 7 the problem of evaporation from land and sea is briefly presented. In the last chapter, reflecting the author's wide interest to the various fields of meteorology, he attempts to apply the theory of the boundary layer to the problem of air mass modification. The role and relative importance of various factors which affect air mass modification are discussed. There is no doubt that this part will be welcomed by dynamic and synoptic meteorologists and will give them several clues for simple methods of incorporating these effects.

The reviewer believes that this book will surely accelerate progress in the field of micrometeorology and in neighboring fields. Perhaps Priestley would be pleased if this up-to-date book becomes out-of-date as soon as possible.

Syukuro Manabe

E. Z. VOGT and RAY HYMAN, *Water Witching USA*, Univ. of Chicago Press, 250 pp., 1959, \$4.95.

This is not the first time in the last four or five centuries that someone has taken a long, hard look at water witching and written about it. In fact the books, pamphlets, and sermons on dowsing, divining, witching, or doodlebugging would doubtless fill a small library. Most of these, however, are devoted to only one aspect of the field, either the diviner or the methods of divining.

It has remained for Vogt and Hyman, one an anthropologist and the other an ex-magician turned psychology professor, to back away from the individual and the specific so they could examine the whole broad field in context. They have studied not only the witching technique, but the related activities where 'extrahuman' forces are supposed to be working. Finally they have turned their attention to witching as a social phenomenon by asking who does the dowsing, and under what circumstances.

They answer the question, "Does it work?" by describing case histories and then controlled experiments. Their review of case histories and field tests shows that testimony of this sort does not offer a basis for comparison, not even with the results obtained by chance or any alternate method of making a choice of location. From the evidence of case histories they go to controlled experiments

where the dowser has nothing to guide his unconscious choice. From all this they conclude that the evidence in support of witching is "appallingly negative." As part of their study of a social custom they then develop a number of theories to explain why witching persists despite the lack of a scientific basis. Many geologists may remember these theories as part of a short article by Hyman and Vogt in *GeoTimes*, March, 1958.

The authors found that two of these theories had validity. As a part of their study they sent questionnaires to several hundred county agricultural agents to measure the extent of witching in rural areas. These questions explored the extent of witching, the ease or difficulty of finding water, and the background of the people who are locating wells by divination. From the replies they established that witching is used where water is hard to find and drilling involves some risk, and where knowledge about the occurrence of ground water is wanting.

After having explored witching as a water-finding technique and as a social custom, they ask the question, "Why does the rod move?" In many ways this is the most important chapter, as it gives the actual mechanics of witching. They cite an experiment by a Father Kircher in 1641, who clearly demonstrated that the rod would not move except when held by a person. Vogt and Hyman then explore what they call the psychophysics of the divining rod. They ascribe the unconscious control of the rod by the operator to "ideomotor action." They link this to suggestibility which acts as a trigger mechanism.

This book is an excellent study of a long-established human custom that has no sound scientific basis. It also explores our society to show why the custom persists and lastly proposes an explanation on the basis of a study of man himself. In an appendix a geologist, H. E. Thomas, outlines the scientific methods of finding water.

Charles T. Snyder

List of Recent Books of Interest and Importance to Geophysicists

- AMERICAN ASTRONAUTICAL SOCIETY, *Advances in Astronautical Sciences*, vol. 4, Plenum Press, New York, Chapman and Hall, London, 460 pp., 1959, \$8.00.
- ANNALS OF THE INTERNATIONAL GEOPHYSICAL YEAR, Vol. 1, Historical Volume, Pergamon Press, 446 pp., 1959, \$17.00; Part I—The First International Polar Year, Part II—The Second International Polar Year, Part III—The Inception and Development of the International Geophysical Year.
- ANNALS OF THE INTERNATIONAL GEOPHYSICAL YEAR, Vol. 2A, General CSAGI Meetings, 395 pp., 1959, \$17.00; Parts I-IV concern First, Second, Third, and Fourth CSAGI Meetings, respectively.
- ANNALS OF THE INTERNATIONAL GEOPHYSICAL YEAR, Vol. 2B, Subject-matter CSAGI Meetings, 460 pp., 1959, \$17.00, Part V—Antarctic, Part VI—Arctic, Part VII—Regional, Part VIII—Discipline Conferences.
- ASSOCIATION DE VOLCANOLOGIE, IUGG, *Bulletin Volcanologique*, ser. II, tome XXI, 178 pp., 1959. (Contains ten papers by various authors presented at XI General Assembly of IUGG, Toronto, 1957.)
- ASSOCIATION INTERNATIONALE DE GEODESIE, IUGG, *Bulletin Géodésique*, no. 50, 93 pp., 1958. (Contains one report and seven papers by various authors on geodetic subjects.)
- BATTAN, LOUIS J., *Radar Meteorology*, Univ. of Chicago Press, 176 pp., 1959, \$6.00.
- BERNHARDER, DANIEL (ed.), *The Magnetodynamics of Conducting Fluids*, Stanford Univ. Press, viii + 145 pp., 1959, \$4.50.
- CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, *La Topographie et la Géologie des Profondeurs Océaniques*, CNRS, Paris, 313 pp. + map, 1959.
- COLLIN, ALEXANDRE, *Landslides in Clays*, 1846, Univ. of Toronto Press, 160 pp., 1956, \$6.50.
- COLORADO SCHOOL OF MINES, *Third Annual Rock Mechanics Symposium*, Colo. School of Mines Quarterly, 54, no. 3, 370 pp., 1959.
- COULSON, KINSELL L., *The Flux of Radiation from the Top of a Rayleigh Atmosphere*, Univ. Calif., Los Angeles, Dept. of Meteorology, Scientific Rep. no. 1, 176 pp., 1959.
- FAITH, W. L., *Air Pollution Control*, Wiley, New York, vii + 259 pp., 1959, \$3.50.
- FLÜGGE, S. (ed.), *Handbuch der Physik*, vol. 41, pt. 1, *Nuclear Reactions 2: Theory*, 587 pp., 145 marks; vol. 44, *Nuclear Instrumentation 1*, 480 pp., 125 marks; vol. 52, *Astrophysics 3: The Solar System*, 608 pp., 148 marks; vol. 53, *Astrophysics 4: Stellar Systems*, 573 pp., 142 marks, Springer, Berlin, 1959.
- FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, *Current Bibliography for Aquatic Sciences and Fisheries*, FAO, Rome, 146 pp. + author index, 1959.
- FRENKIEL, F. N., AND P. A. SHEPPARD (eds.), *Atmospheric Diffusion and Air Pollution*, Academic Press, New York and London, 1959.
- GLAZOV, N. V., AND A. N. GLAZOV, *New Instruments and Methods of Engineering Geology* (translated from Russian by J. Paul Fitzsimmons), Consultants Bureau, N. Y., Chapman and Hall, London, 91 pp., 1959, \$3.25.
- HAGAN, ROBERT M. (ed.), *First Intersociety Conference on Irrigation and Drainage*, U. S. National Committee, International Commission on Irrigation and Drainage, P. O. Box 7826, Denver 15, Colo., 134 pp., 1959, \$4.50.
- HIGHWAY RESEARCH BOARD, NATIONAL ACADEMY OF SCIENCES, *Water and Its Conduction in Soils*, 338 pp., 1959, \$6.00.

- INTERNATIONAL OCEANOGRAPHIC CONGRESS, Preprints, Amer. Assoc. Adv. Sci., 1022 pp., 1959.
- JARDETZKY, WENCESLAS S., *Theories of Figures of Celestial Bodies*, Interscience Publishers, New York and London, 195 pp., 1958, \$6.50.
- KRAMP, P. L., *The Hydromedusae of the Atlantic Ocean and Adjacent Waters*, Carlsberg Foundation, Copenhagen, 283 pp., 1959, Kr. 60.
- KRASOVSKIY, V. I. (ed.), *Spectral, Electrophotometrical, and Radar Researches of Aurorae and Airglow*, Royer and Roger, New York, no. 1, 36 pp., 1959 (translation of seven papers originally published by Academy of Sciences of USSR in 1959 relating to Section IV of IGY program).
- LAUBER, PATRICIA, *All about the Ice Age*, Random House, New York, 151 pp., 1959, \$1.95.
- LOEBACK, THEO, *Our Atmosphere*, Pantheon, New York, 256 pp., 1959, \$5.00.
- NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL, *Arctic Sea Ice*, NAS-NRC publ. 598, 271 pp., 1958, \$4.00.
- NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL, *Radioactive Waste Disposal into Atlantic and Gulf Coastal Waters*, NAS-NRC publ. 655, 37 pp., 1959, \$1.00.
- NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL, *Radioactive Waste Disposal from Nuclear-powered Ships*, NAS-NRC Publ. 658, 52 pp., 1959, free.
- NEUBERT, KARL, AND WALTHER STEIN, *Plan- und Rieskunde*, Band 1, Bergakademie Freiberg, Fernstudium, 249 pp., 1958.
- PRIESTLEY, C. H. B., *Turbulent Transfer in the Lower Atmosphere*, Univ. of Chicago Press, 136 pp., 1959, \$3.75.
- REINFELD, FRED, *Uranium and Other Miracle Metals*, Sterling, New York, 128 pp., 1959, \$3.95.
- RILEY, CHARLES M., *Our Mineral Resources*, Wiley, New York, x + 338 pp., 1959, \$6.95.
- SHAPLEY, HARLOW, SAMUEL RAPPORT, AND HELEN WRIGHT (eds.), *A Treasury of Science*, Harper, New York, 4th edition, xiii + 776 pp., 1958, \$6.95.
- SHAW, MARK D., AND WILLIAM C. ARBLE, *Bibliography on Methods for Determining Soil Moisture*, Pa. State Univ., Eng. Res. Bul. B-78, 152 pp., 1959, \$2.00.
- SHEPARD, FRANCIS P., *The Earth beneath the Sea*, Johns Hopkins Press, Baltimore, xii + 275 pp., 1959, \$5.00.
- SIXTH COMMONWEALTH MINING AND METALLURGICAL CONGRESS, *Methods and Case Histories in Mining Geophysics*, Mercury Press, Montreal, 359 pp. + maps.
- SLOTNICK, MORRIS MILLER, *Lessons in Seismic Computing*, Society of Exploration Geophysicists, 268 pp., 1959.
- SMITH, L. G., (ed.), *Recent Advances in Atmospheric Electricity, Proceedings of the Second Conference on Atmospheric Electricity*, Pergamon Press, 631 pp., 1958, \$17.50.
- SMITHSONIAN INSTITUTION ASTROPHYSICAL OBSERVATORY, *Special Reports 1-27*, multilith reports carrying data on satellites, 1958 and 1959.
- STROYATSKIY, S. I., *Some Characteristics of Surface Disturbances in Magnetohydrodynamics*, Royer and Roger, Inc., New York, 45 pp., 1959.
- TUNNELL, G. A., *World Distribution of Atmospheric Water Vapour Pressure*, Geophysical Memoirs, no. 100, i + 61 pp., 1958, 10 shillings.
- UNITED NATIONS, *Proceedings of the Third Regional Technical Conference on Water Resources Development in Asia and the Far East*, Flood Control Series no. 13, 173 pp., 1958, \$1.75.
- VINOGRADOV, A. P., *The Geochemistry of Rare and Dispersed Chemical Elements in Soils*, translation by Consultants Bureau, New York, for the Geochemical Society, 209 pp., 1959, \$9.50.
- WEENINK, M. P. H., *A Theory and Method of Calculation of Wind Effects on Sea Levels in a Partly-Enclosed Sea, with Special Application to the Southern Coast of the North Sea*, Kon. Ned. Met. Inst., Meded. Verhandelingen no. 73, 111 pp., 1958.
- WHEELER, ROBERT R., AND MAURINE WHITED, *Oil—From Prospect to Pipeline*, Gulf Publishing Co., Houston, 115 pp., 1958.
- WHITE, GUT KENDALL, *Experimental Techniques in Low-Temperature Physics*, Oxford Univ. Press, New York, 246 pp., 1959, \$7.20.
- WHITELOCK, OTTO V. ST., FRANKLIN N. FURNESS, AND KURT E. LOWE (eds.), *Modern Aspects of the Geology of New York City and Environs*, Annals N. Y. Acad. Sci., 80, 1047-1170, 1959, \$2.50. (Contains nine papers presented at a conference held by the New York Academy of Sciences, December 6, 1958.)
- WORLD METEOROLOGICAL ORGANIZATION, *Use of Ground-Based Radar in Meteorology*, 80 pp., 1959, 9 francs (report of a working group of the Commission for Instruments and Methods of Observation prepared by six authors).

Contents of Bulletin (Izvestiya), Academy of Sciences, U.S.S.R. Geophysics Series, May-December, 1958

Note—The March, 1959, issue of the *Transactions*, pages 28-31, lists the contents of *Izvestiya, Geophysics Series* for January-September, 1957. The June issue of the *Transactions*, pages 124 and 125, lists the contents for October-December, 1957. In the September issue, the contents for the first

four numbers of 1958 are listed, pages 228-229. Below are listed the contents for the eight numbers, May-December, 1958. The production of the English edition of *Izvestiya* for 1957 was undertaken on behalf of the American Geophysical Union by Pergamon Press, with the aid of a grant

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The production of the twelve numbers issued in 1958 is being undertaken directly by the American Geophysical Union, with the aid of a grant from the National Science Foundation. Subscriptions for the volume, numbers sent as issued, are \$25.00.

It is anticipated that the first number of 1959 will be available early in 1960, and that by mid 1960, the twelve numbers for 1959 will be available in the English edition. By the end of 1960, it is the plan that the numbers will be current.

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English Translations of Russian Scientific Journals and Papers

Many more translations of Russian scientific writings are available than is generally realized. In order to indicate what is available, the Office of Technical Services of the U. S. Department of Commerce has begun a semi-monthly publication entitled *Technical Translations* which lists translations, not only from the Russian but from other languages as well, available through various organizations in the United States, Canada, Great Britain, and Australia. Some of these are translations in full; others are abstracts of papers in journals, as indicated below. The following information bears on subjects that are likely to be of special interest to geophysicists.

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ABSTRACTS OF PAPERS IN JOURNALS
AND COMPLETE JOURNALS

- Izvestiya, Akademii Nauk SSSR, Seriya Geologicheskaya* (Bulletin, Academy of Sciences, USSR, Geology Series); OTS, \$0.50 per copy.
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- Note: LIST OF TRANSLATIONS; Defence Research Board, Ottawa, Canada, has prepared a list of its translations as of April 30, 1959, including 324 Russian items, 3 Yugoslav, 1 Ukrainian, 4 Polish, 14 Japanese, and 6 Chinese.

Notes and Personalia

Notes

• CONTINUED WORK IN THE ANTARCTIC—The National Science Foundation announces that the United States' scientific effort in the Antarctic will be supported beginning in October 1959 by grants totaling over \$3,000,000. It is noted that 35 scientists will remain in the Antarctic through the 1960 Antarctic winter, while twice this number will be engaged in summer activity. The Ant-

arctic Biological Research Laboratory at McMurdo will be in operation, this having been built by a grant from the Foundation of \$82,000 to the Arctic Institute of North America. Details on the plans may be secured by writing to the National Science Foundation. A paper about the background and general features of the Antarctic work appears in this issue of the *Transactions*.

The Foundation has announced that final proposals for Antarctic research for the field season 1960-1961 should be filed by February 15, 1960. Proposals should be addressed to Director, National Science Foundation, Washington 25, D. C., Attn: Arctic Program Director.

● **WORLD MAGNETIC SURVEY OF THE HYDROGRAPHIC OFFICE**—The U. S. Navy Hydrographic Office has announced its plans for an extensive aerogeomagnetic survey of ocean areas, the program designated as Project Magnet. It is essentially a world-wide extension of the aeromagnetic survey of the North Atlantic Ocean completed several years ago and which yielded much valuable information and experience in this relatively new and unique method of charting the Earth's magnetic field. It is the plan of the survey to secure and to maintain on a reasonably current basis, accurate geomagnetic data in all accessible ocean areas, with the operations extending over polar regions and, with permission of other countries, over land areas where little or no magnetic data are available. The results of the survey should have a profound effect upon the navigational and isomagnetic charting programs and, incidentally, the project seems to fit in well with the projected plan of the International Union of Geodesy and Geophysics to sponsor a world geomagnetic survey [see *Transactions*, AGU, September 1959, page 264]. It should provide excellent supporting data for further analytical studies of the Earth's magnetic field.

The flight survey operations are already underway employing two especially configured transport-type aircraft. Aircraft WV-2, a Super Constellation, has already completed survey tracks on its return to the United States after extensive operations in the South Pacific Ocean, including the waters surrounding Australia. The R5D, a Skymaster, has completed tracks over the North Pacific Ocean, the Philippine and China Seas, to Bangkok, Thailand, and will traverse the Indian and South Atlantic Oceans as well as the continents of Africa and South America before returning to the United States.

It is planned to coordinate this work with that planned by the International Union of Geodesy and Geophysics, and the proposal has been made that in connection with that meeting a general report on the survey and its progress up to that time be presented before the International Association of Geomagnetism and Aeronomy. Bernard C. Byrnes, Head of the Geomagnetism Branch of the Hydrographic Office, which group is undertaking this work, expects to be in attendance at the meeting to aid in presenting the reports and the inspection of the plane.

● **STUDY OF IONOSPHERIC-ELECTRON DENSITY**—The Central Radio Propagation Laboratory of the National Bureau of Standards at Boulder, Colorado, has announced a plan for the systematic collection of data on the ionospheric-electron density by taking hourly vertical soundings at ionosphere stations operated by the Central Radio Propagation

Laboratory and the U. S. Army Signal Corps. The work is already under way at the station in Puerto Rico and the computations will be performed at the Boulder Laboratories using the matrix method developed by K. G. Budden of the Cavendish Laboratory of Cambridge University programmed for an IBM 650 computer. Details may be secured by addressing IGY World Data Center A, Airlow and Ionosphere, Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado.

● **TRANSLATION WORK FROM RUSSIAN SCIENTIFIC LITERATURE**—The National Science Foundation notes that their survey reveals that there are 2026 scientific journals and serials being published in the U.S.S.R. Seventy-six of these are now available in English. They are listed in the *Monthly Index of Russian Accessions* published by the Library of Congress as well as in the publication entitled *Technical Translations* issued by the Office of Technical Services of the Department of Commerce. AGU's efforts in this include the translation of *Izvestiya* of the Academy of Sciences, U.S.S.R., Geophysics Series. (The volume for 1958 is now completely translated and publication will be completed by about the end of 1959, and by mid-1960 it is anticipated that the 1959 volume will be complete and that we can proceed with 1960. Subscription price, \$25.00 for each of these calendar years.) Also, four numbers of *Trudy* of the Geophysical Institute in Moscow are being translated and will be published in book form early in 1960. These will be available through Consultants Bureau, Inc., 227 West 17th Street, New York 11, New York.

● **AIR WEATHER SERVICE SEEKING METEOROLOGISTS**—The Air Weather Service Headquarters at Scott Air Force Base, Illinois, is accepting applications from qualified individuals with permanent Civil Service status for meteorologist positions in grade GS-11 and above. Interested persons should write to the Service, Attention: AWSPP, Scott Air Force Base, Illinois.

● **PROBABILITY MATHEMATICS IN HYDROLOGY**—The U. S. Geological Survey, using probability mathematics in the analysis of water-supply problems, has come to a conclusion that there is a limit to the practical gains which can be accomplished by building reservoirs on streams and "that limit has already been reached . . . on some western streams." The study is outlined in Survey Circular 409, entitled *Water Yield and Reservoir Storage in the United States* by Walter B. Langbein. Further studies are included in Survey Circular 410 entitled *Probability Analysis Applied to a Water-Supply Problem* by Luna B. Leopold.

● **ATMOSPHERIC SCIENCES ADVISORY PANEL OF NSF**—The National Science Foundation has appointed a Panel for its program in Atmospheric Sciences consisting of Thomas F. Malone, Walter H. Munk, Walter Orr Roberts, Verner E. Suomi, Arthur H. Waynick, and E. J. Workman. The Director of the Atmospheric Sciences program is Earl G. Droessler.

• **EXPANDED OCEANOGRAPHIC PROGRAM IN CANADA**—The Department of Mines and Technical Surveys in Canada is expanding oceanographic work greatly, noting that Canada possesses the longest coastline of any country in the world. A new \$3,000,000 oceanographic institute is being set up on the east coast in Bedford Basin near Halifax. It is anticipated that it will be complete in 1964, have a staff of some 300 scientists plus supporting workers, and have an operating fleet of ten oceanographic vessels, the first of which is the \$7,000,000 C.G.S. *Hudson* which will be commissioned in 1961.

• **NEW GIANT RADIO TELESCOPE**—The Navy is building a radio telescope at Sugar Grove, West Virginia, 600 ft in diameter, which should theoretically be able to penetrate space to 38 billion light years, 19 times the distance of the range of the 200-inch optical telescope at Mount Palomar, California. The largest radio telescope now in operation is the 250-ft one at Jodrell Bank, England, and Soviet scientists are understood to be building one 350 ft in diameter. A 140-ft telescope is now under construction at Green Bank, West Virginia, 30 miles from the one now being built by the Navy.

• **MACHINE TO HELP PROGRAMMING LARGE SCIENTIFIC MEETINGS**—In order to study the problems of the planning of large scientific meetings, the National Science Foundation has made a grant to the Federation of American Societies for Experimental Biology. A test will be made by machine methods to schedule the thousands of scientific papers that are read at large meetings of professional and academic societies in an effort to eliminate conflicts and to group related papers into the same program, thus making attendance by individual scientists more effective. Specifically, a trial of machine-based methods will be made in the programming of the 1960 meeting of the Federation to be held in Chicago, April 11-15. At the 1959 meeting 2383 ten-minute papers were scheduled in 235 separate sessions held over a five-day period. A similar program is anticipated for 1960 and a comparison of machine results with the results of the old system will be made.

• **PLANS FOR AN ORBITING TELESCOPE**—The Applied Research Laboratory of the University of Arizona is engaged in research that may lead to the solution of the problem of developing a telescope mounted on a satellite orbiting around the Earth, a great advantage being the elimination of the atmosphere between the telescope and the observed bodies. A contract to support this work has recently been entered into by the University and the Association of Universities for Research in Astronomy (AURA), which is establishing the new National Astronomical Observatory near Tucson. A. B. Meinel, Director of the National Observatory, has predicted that space telescopes may be in use within the next five to ten years.

• **NEW SCIENTIFIC CRUISE OF THE VEMA**—Columbia University's Research Vessel *Vema* has left for Antarctic waters on a ten-month scientific

cruise that will include circumnavigation of the Antarctic Continent. This will be the most extensive of the *Vema's* cruises, which total 15 up to the present. In announcing the trip, Director Maurice Ewing noted that "In the trip around the Antarctic Continent, the ship will sail as close to the ice as possible, but it will not be able to cross the Antarctic circle. Even though it will be summer when it arrives in that area, the ice will prevent our ship from going south of the circle." Ocean-bottom cores will be taken as near the ice as possible, and it is hoped that these will indicate changes in climate going back millions of years and show whether the weather in that frigid area was at one time much different than it is now. One objective of the cruise is to obtain more information about the 4500-mile rift discovered in the floor of the oceans by the Columbia group. It is noted that the rift averages about 20 miles wide and 1-½ miles deep, and coincides with the world-wide active earthquake zone along its entire length. The *Vema* is scheduled to return to New York in July, 1960.

The *Vema* returned from a nine-month cruise in the Atlantic and Pacific Oceans and the Caribbean Sea on July 15, 1959. The cruise included work on the projected boring of a hole through the Mohorovicic Discontinuity, now popularly referred to as the Mohole. Data gathered on the cruise included also heat-flow studies from the ocean's floor and the securing of long cores (one 72 ft long) especially in the Pacific where 11 samples revealed a layer of clean white ash extending over a vast area which was announced some months ago.

• **NEW SCIENTIST EXCHANGE PACT WITH THE U.S.S.R.**—A new scientist exchange pact has been agreed to by the U. S. National Academy of Sciences and the National Academy of Sciences of the U.S.S.R., calling for lectures, research work, and observational studies by scientists and for the organization of symposia on current scientific problems. It is anticipated that 90 scientists will take part in the two-year program, which provides for possible continuation after that interval.

• **MEANS OF EXPEDITING WEATHER FORECASTING**—A new system, sponsored jointly by the Air Force, the Federal Aviation Agency, and the Weather Bureau, is expected to cut down by two-thirds the interval between observation and forecast by the use of computers and automatic observation stations. The computer, replacing the human forecaster, will process the data and transmit its prediction to automatic display devices in airport control towers, pilot briefing rooms, and Weather Bureau offices. The tentative plan involves its going into operation in northeastern United States by 1963. There will be ten stations in the test net ranging from Norfolk, Virginia, to Boston, Massachusetts.

• **NEW AIRBORNE RADIOMETER**—A new radiometer has been designed and developed by the Naval Research Laboratory for the purpose of taking measurements of radiant energy from the ocean

in relationship to the optics of the atmosphere and the sea. This is a massive radiometer 100 inches in diameter which records continuously the thermal energy radiated by the sea plus a small portion which originates in the sky. Two different configurations are employed, one, a 100-inch parabolic mirror, and the other, a 100-inch mirror split along the diameter and opened 15° to form two independent collecting areas. It has been found that many problems of the sea may be studied by means of the radiometer, as, for example, the fact that man-made oil slicks alter the wave structure and make the surfaces reflect more sky radiation, meaning that the slicks are likely to be colder than the surrounding water.

● **STUDY OF TEKITES**—A grant of \$10,000 has been made by the National Aeronautics and Space Administration to Boston University for the study of these black glassy fragments of controversial origin.

● **NEW DIRECTOR OF METEOROLOGY IN CANADA**—Patrick Duncan McTaggart-Cowan has been named Director of the Meteorological Branch of the Department of Transport of Canada, succeeding Andrew Thomson who has recently retired. The new Director was born in Scotland, educated in Canada and England, and has been active in the development of meteorological activities in the North Atlantic area and in connection with the work of the International Civil Aviation Organization.

● **MAP ON THE STATUS OF AERIAL PHOTOGRAPHY**—The 1959 edition of the index map showing the status of aerial photography in the United States is now available and shows for the first time 100% coverage excepting for a small area in Hawaii. Copies may be secured from the Map Information Office, U. S. Geological Survey, Washington 25, D. C.

● **IGY METEOROLOGICAL OBSERVATIONS**—In 1957 the World Meteorological Organization made arrangements for the availability on microcards of world-wide meteorological observations for the period of the IGY. They now have in hand details regarding partial sets of microcards of surface observations (Form No. 1) and upper-air observations (Forms No. 3 and 4). Details of these can be secured from the World Meteorological Organization in Geneva.

● **STUDIES OF BLUE GLACIER**—Blue Glacier, located on Mt. Olympus in northwestern Washington, is the basis of a study by scientists of California Institute of Technology under the direction of Robert P. Sharp, who notes that glaciers as living dynamic geology offer a possible key to the formation of structures in rocks. This particular project began as an IGY project in 1957 and will continue for at least two more years under a grant from the National Science Foundation and with the concurrence of the National Park Service. The November issue of the *Journal of Geophysical Research* contains a lengthy paper by W. B. Kamb on these studies.

● **NEW SERIES OF LECTURES IN OCEANOGRAPHY**—

New York University has arranged a series of lectures entitled "Oceanographic Aspects of Maintenance of Beaches, Harbors, and Marine Structures" to acquaint engineers and others with the results of oceanographic research and application of these results to various problems. The lectures will involve information gained from the study of ocean waves, currents, tides, storm tides, and other sea-level changes in relation to beach erosion problems, off-shore oil drilling, harbors, and marine structures. The series is being given by Gerhard Neumann, Professor of Oceanography at the University. A second series of lectures will be given in the fall of 1960 under the title "Estuarine Hydrography and Flushing Problems."

● **GRANT PROGRAM OF THE UNITED STATES STEEL FOUNDATION**—The United States Steel Foundation has announced the establishment of a \$2,350,000 program of aid to education, awarding grants to 541 privately supported liberal arts colleges, 125 universities, 22 science and engineering institutes, and 25 organizations devoted to elevating the quality of higher learning in the United States. The grants totaled two-thirds of a million dollars for operating purposes, one million dollars for major-purpose or capital grants, \$180,000 for teaching aids, \$190,000 for fellowships, \$113,000 for specific projects, and lesser amounts for various other purposes including a grant for polar research to the Arctic Institute of North America, to the Lamont Geological Observatory of Columbia University, to Woods Hole Oceanographic Institution, and to Scripps Institution of Oceanography. Inquiries concerning this matter should be addressed to W. Homer Turner, Executive Director, United States Steel Foundation, Inc., 71 Broadway, New York 6, New York.

● **CONTRIBUTION TO SAINT LOUIS UNIVERSITY**—The California Company of New Orleans, Louisiana, has made a gift of a special analog computer to the University. This is especially for handling geophysical problems and will be used in continuing the study of the subsurface structure of the area around St. Louis extending from the western portion of the Illinois basin to the eastern Ozark area. The computer was built by the Stanford Research Institute.

● **LARGE OIL AND GAS CONCESSION IN SOUTHWEST AFRICA**—The Trans-American Mining Corporation, Ltd., 260 Madison Avenue, New York 16, New York, announces that it has been granted an oil and gas concession covering 10,000 square miles in the west central area of Southwest Africa, the first such concession in that region. They plan immediate geophysical surveys of the Namid Desert sedimentary basin, which is included in the concession.

● **NEW CONSULTING FIRM**—A new firm, Facilities Development Planning Corporation, with headquarters in Los Angeles, has been established with Robert B. Hickok as one of its members. As the name implies, it will engage in project planning and project development control, including cost estimates, benefit studies, feasibility apprais-

als, physical investigations, and related matters.

• **FACILITIES ATOP MOUNT WASHINGTON**—The Gorham Laboratories at Gorham, Maine, which operate the Mount Washington Observatory in cooperation with other groups, have just published a brochure outlining the research and testing facilities on Mount Washington. Laboratories and living quarters are available to qualified persons who want to undertake work at the Observatory. This offers opportunities for various types of geophysical research.

• **TOTAL ECLIPSE OF THE SUN**—An eclipse of the Sun, total from the coast of Africa across to the Canary Islands and to the New England coast and other parts of the United States, occurred on October 2. A joint expedition from Sacramento Peak Observatory at Sunspot, New Mexico, and the High Altitude Observatory at Boulder, Colorado, went to the Canary Islands for purposes of observation. This expedition observed the eclipse as part of the follow-up to the International Geophysical Year known as International Geophysical Cooperation—1959. Various other groups including the University of Minnesota, University of Wisconsin, Naval Research Laboratory, and the Boulder Laboratories of the National Bureau of Standards made studies of the eclipse in the zone of totality, and logistic support is being given by the Geophysics Research Directorate of the Air Force Cambridge Research Center.

• **PIT RECHARGE OPERATIONS AT PEORIA**—The eighth full season of pit recharge operations by the Illinois Water Survey Division has now been completed and additional valuable research data on this particular type of recharge have been obtained. The tests were made this season without cleaning or replacing the filter gravel which was placed in 1956, and the infiltration rate was about the same as the preceding two years. Details may be secured by writing to the Survey at Urbana, Illinois.

• **KANSAS CONFERENCE OF TEPS**—The National Commission on Teacher Education and Professional Standards of the National Education Association held its meeting at the University of Kansas in late June, 1959. Frank C. Foley and James A. Peoples, Jr., were AGU's representatives at the conference. The purpose of TEPS is just what the name implies, and in attempting to accomplish this these conferences are held inviting participation by specialists in subject-matter. It is anticipated that a report of AGU's representatives will be published subsequently.

• **INTERNATIONAL OCEANOGRAPHIC CONGRESS**—An International Oceanographic Congress was held by the American Association for the Advancement of Science in cooperation with UNESCO and with the support of various groups at the United Nations Headquarters in New York, Au-

gust 30-September 11. Participants came from many parts of the world. Some 1500 were in attendance. Oceanographic research vessels making special trips to New York for the occasion included the French *Calypto* and the Russian *Mikhail Lomonosov*. The Committee arranging the symposium included Mary Sears, Chairman, Gustaf Arrhenius, John Cushing, Fritz Kocoy, Gordon G. Lill, George S. Myers, Roger Revelle, Henry M. Stommel, and Lionel A. Walford.

• **NATIONAL SCIENCE FOUNDATION PROGRAM FOR GRADUATE AWARDS**—Applications are being accepted for Graduate Fellowship awards for advanced study in the sciences. Fellows, who must be American citizens, will be selected on the basis of ability, academic record, and other evidences of attainment, and are required to take the Graduate Record Examination. Stipends range from \$1800 to \$2200 for the year with special dependency allowances, allowances for tuition, laboratory fees, and travel. Applications should be sent to the National Science Foundation Graduate Fellowship Program, Fellowship Office, National Academy of Sciences—National Research Council, 2101 Constitution Avenue, N.W., Washington 25, D. C., by January 1, 1960.

• **STUDY OF NATIONAL WATER RESOURCE PROBLEMS**—A Senate Select Committee on National Water Resources has been established and hearings have been held at numerous points throughout the country during the fall months. All Federal agencies concerned with water resources have been asked to prepare reports. The Committee is to transmit results of its study to the Senate with recommendations by early 1961. An initial fund of \$175,000 has been appropriated for the work of the Committee, which is under the Chairmanship of Robert S. Kerr, Senator from Oklahoma, and the Vice Chairmanship of Thomas H. Kuchel, Senator from California; Theodore Schad has been named Staff Director.

• **DEPARTMENTAL CHANGES AT THE UNIVERSITY OF CINCINNATI**—Effective September 1, the University of Cincinnati has established a Department of Geology and a Department of Geography, these two having formerly been joined. William F. Jenks is the head of the Department of Geology. Space for new laboratories is being developed for work in geochemistry, crystallography, crystal chemistry, hydrothermal geology, and sedimentology.

• **NEW DIVISIONS AT ARGONNE NATIONAL LABORATORY**—Argonne National Laboratory has announced the formation of two new major divisions, one for high-energy physics and one for solid-state physics. Roger Hildebrand has been named Acting Director of the former, and Oliver C. Simpson Director of the latter.

Personalialia

- JOHN N. ADKINS, former Director of the Earth Sciences Division of the Office of Naval Research, has been named Deputy Research Director of the same organization.
- LEROY R. ALLREDGE, President of the Section of Geomagnetism and Aeronomy, AGU, and formerly Research Analyst with the Operations Research Office of Johns Hopkins University, has been named Research Geophysicist with the U. S. Coast and Geodetic Survey. This is the first appointment made by the Survey under Public Law 313 covering high-level scientific positions. The position involves responsibility for planning and conducting studies in basic physical principles governing the behavior and interaction of the Earth's magnetic field, the ionosphere, and cosmic radiation.
- CHARLES A. ANDERSON has been designated as Chief Geologist for the U. S. Geological Survey, which position had been held by Wilmot H. Bradley since 1944.
- STANLEY S. BALLARD has been named Chairman of the Department of Physics at the University of Florida in Gainesville.
- HAROLD E. BARBITT, Professor Emeritus of Civil Engineering at the University of Illinois, has been appointed Visiting Professor at Iowa State University at Ames.
- JEAN CLAUDE DE BREMAECKER has resigned his position with the Institute for Scientific Research in Central Africa (IRSAC) and has accepted an appointment as Assistant Professor of Geophysics and Geology at Rice Institute.
- ROBERT A. EARLE has been named Chief of the Division of Geophysics of the U. S. Coast and Geodetic Survey, succeeding Elliott B. Roberts.
- GORDON M. FAIR, Professor of Sanitary Engineering at Harvard University, has recently delivered the Chadwick Lecture to the Health Congress of the Royal Society of Health in Harrogate, England, on the subject "New Factors in Man's Management of his Environment."
- FRANK GOLDSTONE has retired from the Shell Oil Company and has taken up duties with the Petty Geophysical Engineering Company in San Antonio, Texas.
- CHARLES S. HEIDEL, Deputy State Engineer of Montana, has been awarded honorary membership in the Montana Society of Engineers.
- GEORGE J. HEINSHIMER has been elected to membership in the Academia Argentina de Geografia.
- FREDERICK L. HOTES, who has been on an assignment as Chief of the Water Conservation Division on the work of the Development and Resources Corporation of New York in Iran, has been named Chief of the Division of Water Resources Development in the consulting and research engineering firm of Engineering-Science, Inc., at Oakland, California.
- DON KIRKHAM has been named Charles F. Curtiss Distinguished Professor in Agriculture, Professor of Soils and Physics, at the Iowa State College of Agriculture and Mechanic Arts.
- ALFRED LOEHNEBERG, who has been in Mexico on a UNESCO assignment in connection with water resource studies, has been appointed a Hydrologic Consultant to the Ministry of Hydraulic Resources and to the Water Works Department of the Federal District.
- FRED E. MOORE has been named Assistant Professor of Geology at Colorado School of Mines.
- J. HOLLOWAY MORGAN has retired as District Engineer of the Water Resources Division of the U. S. Geological Survey at Champaign, Illinois, after more than 45 years of Government service.
- LOUIS O. QUAM, formerly Head of the Geography Branch of the Office of Naval Research, has been named the Director of the Earth Sciences Division, succeeding John N. Adkins.
- LOUIS L. RAY is on leave from his duties with the U. S. Geological Survey during the current academic year and is serving as Visiting Professor of Geology at Cornell University.
- NORMAN H. RICKER, who was formerly Senior Research Physicist for the Carter Oil Company in Tulsa, Oklahoma, has taken up duties as Professor of Physics at the University of Oklahoma.
- ELLIOTT B. ROBERTS has retired from the U. S. Coast and Geodetic Survey where he has been serving as Chief of the Division of Geophysics. He has been retained temporarily as a Special Assistant for Research and Development.
- MILTON O. SCHMIDT, Professor of Civil Engineering at the University of Illinois and retiring President of the Section of Geodesy, AGU, is on a sabbatical year's leave from his duties under a NSF Science Faculty Fellowship for study at the Swiss Polytechnic Institute in Zurich, Switzerland.
- LORENZ G. STRAUB, Director of the St. Anthony Falls Hydraulic Laboratory and Head of the Civil Engineering Department at the University of Minnesota, has been elected an honorary member of the International Association for Hydraulic Research. He is the first honorary member from the Western Hemisphere and only the fifth in the 23-year history of the Association.
- MANIK TALWANI, an Indian national who received his doctor's degree from Columbia University last June, has been engaged in scientific work aboard a British submarine which has been engaged in oceanographic studies for Columbia University and the Union of South Africa. The work has been in progress along the west coast of Africa, chiefly in the matter of making a pendulum gravity survey.
- ROBERT A. WARNER is on an assignment with Delhi Australian Petroleum Ltd. to work as a Geologic Supervisor on their 137,000-square-mile concession in the Gulf of Carpentaria near northern Queensland, Australia.

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- **LEAVITT JAMES BULKLEY**, Chairman of the Board of Cranbrook Institute of Science in Bloomfield Hills, Michigan, died June 23, 1958, at the age of 64. He was born in New York City. He took his baccalaureate degree from the University of Michigan in 1917. His lifetime was devoted to commercial and civic pursuits, and at the time of his death he was President of the Commonwealth Brass Corporation and of the civic group known as the Friends of the Detroit Public Library. He became a member of the American Geophysical Union in 1957.
- **JAMES EDWARD CHURCH**, frequently referred to as the father of snow surveying, died in Reno, Nevada, August 5, 1959, at the age of 90. He was born at Holly, Michigan, and in 1892 took his baccalaureate degree from the University of Michigan. He took his doctorate from the University of Munich in 1901 and was awarded an honorary doctorate by the University of Nevada in 1937. The early part of his career was devoted to classical studies in archeology and in Latin, and in 1939 he retired from the University of Nevada as Professor of Latin and German. Early in his career he became interested in various aspects of meteorology, notably in snow, and in 1905 he was one of the founders of Mt. Rose Meteorological Observatory. He was a meteorologist on the Michigan-Greenland Expedition, 1926-1928, and since retiring from his professorial duties at the University of Nevada he took up duties as a snow specialist in connection with the Nevada Agricultural Experiment Station and the Weather Bureau. His work at Mt. Rose included the development of the Mt. Rose snow sampler and led to the establishment of snow-survey courses in an effort to arrive at a quantitative hydrologic value for anticipated runoff. As a specialist in this field, he received calls from India, Argentina, and other countries to lay out snow courses and to train technologists in the matter of their operation. He was active in the International Association of Hydrology, IUGG, and was President of the Commission on Snow from 1933 to 1939, and of the Commission on Snow and Glaciers, its successor, from 1939 to 1948. He was President of the Section of Hydrology of AGU from 1942 to 1947. He had been a member of AGU since 1934.
- **VERNON D. GEORGE**, Vice President and Treasurer of the consulting engineering firm of Seybolt and George, Inc., died August 3, 1959, at the age of 61. He was born at Bayonne, New Jersey. By dint of his own initiative, he became a specialist in the matter of triangulation, horizontal and vertical control, and the matter of property surveys. For 17 years he served as Deputy Chief Engineer in Charge of Surveys with the Washington Suburban Sanitary Commission, and in the mid-1940's retired from this work to become one of the founders of the firm of Seybolt and George. He had been a member of AGU since 1943.
- **NORMAN RANDOLPH HAGEN**, meteorologist, and Coordinator of Public Information of the Weather Bureau since 1955, died August 15, 1959, at the age of 52. He was born at Crookston, Minnesota. He took his academic work at Catholic and George Washington Universities in Washington, D. C., and entered the service of the Weather Bureau in 1928. He was on the staff of meteorologists that supplied the Supreme Commander with forecasts for the Normandy D-Day invasion, and after the war was the first American Meteorological Attaché to London and Moscow, continuing until 1952. He had been a member of AGU since 1942.
- **MARK R. KULP**, State Engineer of Idaho, was killed in an automobile accident on June 9, 1958. He was about 70 years old. He was born in Colorado, and in 1908 took his baccalaureate degree from Colorado A and M College. He was returning from the fiftieth class reunion at the time of his accident. He had broad experience in irrigation work, and before taking up duties as State Engineer of Idaho in 1944 had spent some 30 years as a teacher at his alma mater. He had been a member of AGU since 1937.
- **ALPHONSE R. SCHMITT**, member of the Society of Jesus, and Chairman of the Department of Physics at Loyola University in Chicago from 1931 to 1952, died August 28, 1959, at the age of 74. He was born at Wheeling, West Virginia, and took his baccalaureate degree at St. Louis University. In 1917 he began his teaching work at Creighton University. Ill health forced his complete retirement in 1954. He had been a member of AGU since 1939.

Union, Section, and Committee Activities

Addendum to the Progress Report of the Committee for the Study of the Metric System in the United States*

The accompanying tabulation (see next page) of 1080 replies to the Committee's Metric questionnaire, as a sequel to a similar analysis published in the September *Transactions*, confirms our belief that nine out of ten scientists and engineers in the United States are convinced that conversion to the Metric System would be to their advantage. The completed questionnaires and many supporting letters were returned by the readers of eight of the leading technical magazines of the United States in response to the poll of last spring.

Attention is called to the average of 22 years as the recommended period of transition between the passage of the enabling act by the Congress and the date when the Metric System becomes the only official system of weights and measures in the United States. A long transition period is mandatory and will provide opportunity for the change to be made with a minimum of economic dislocation in such a highly industrialized country as ours; it will give adequate time for educational emphasis on the Metric System, for normal obsolescence of heavy equipment, and for the retirement of personnel now imbued with the English units. The Committee estimates that once the country has embarked on the needed change, fully 80% of the change-over will have been effected in 10 years or less, because of an impatient desire on the part of our people for the comparative simplicity inherent in the Metric System. The English units, however, would continue to be entirely legal throughout the entire transition period.

No action toward a study or adoption of the Metric System has occurred in the Congress from the early 1930's until this year. That renewed interest in this subject is great is evinced by the fact that three pertinent bills were introduced in the 86th Congress. Both H.R.7401, May 1959, by Representative Brooks and S2420, July 1959, by Senator Neuberger, call for a study of the Metric System by the Department of Commerce, with final reports due in one and three years respectively. House Concurrent Resolution 364 was introduced in July by Representative Fulton; if passed, it would place the Congress on record as urging the adopting of the Metric System in the United States wherever practicable. Appropriate funding for the studies is provided in the Senate and House bills.

It appears that the great majority of scientific and engineering personnel in the United States believes that the orderly Metric System should gradually replace the archaic English units of weights and measures. In the coming months while the above-mentioned bills are under Committee consideration and subsequently, we trust, a subject of debate in the Congress, we have a splendid opportunity to exercise our right of petition in the interest of a matter of high importance to the nation. Let us not fail to make every rightful effort among the public at large in support of the proposed comprehensive study in the Department of Commerce. It is late but not too late for the United States to move out of the isolated position we stubbornly hold among the remaining ten percent of the world's population not now under the Metric System.

FLOYD W. HUGH, *Chairman*

* See September 1959 *Transactions*, pp. 256-258.

TABLE 1 (revised)—Analysis of Questionnaire on the Metric System

Profession ^a	Present usage (Ques. 2)			Change advantageous (Ques. 3)		Period for change (Ques. 4)		Use Centigrade temperature (Ques. 5)		Export trade now suffering (Ques. 6)		Metric system adoption inevitable (Ques. 7)		Cost of gradual change prohibitive (Ques. 8)		Sponsorship (Ques. 9)			
	Metric	British	Other	Answering	Yes	No	Average	Yes	No	Yes	No	Yes	No	Yes	No	Prof. Soc.	Industry	Education	Government
	%	%	%	%	%	%	years	%	%	%	%	%	%	%	%	%	%	%	%
1	133	37	59	5	95	82	18	98	22	94	85	15	95	65	35	98	16	84	96
2	149	68	29	3	99	93	7	99	22	97	95	5	98	67	33	41	65	35	98
3	160	74	24	2	99	96	4	99	21	96	98	2	99	61	39	43	72	28	97
4	179	24	73	3	98	90	10	99	21	96	94	6	99	50	50	50	50	50	100
5	121	41	56	2	97	90	10	100	25	97	97	3	98	72	28	38	60	39	72
6	84	15	80	5	98	81	19	100	24	95	88	12	98	64	36	60	72	28	98
7	39	45	55	5	92	82	18	95	12	98	64	36	60	72	28	38	60	39	72
8	38	16	83	2	98	82	18	95	12	98	64	36	60	72	28	38	60	39	72
9	19	72	27	2	100	100	20	100	20	100	100	0	100	100	0	100	0	100	100
10	9	75	23	3	100	100	20	100	20	100	100	0	100	100	0	100	0	100	100
11	31	48	44	8	94	100	22	100	22	91	100	0	100	100	0	100	0	100	100
12	11	27	73	100	100	100	22	100	22	92	100	0	100	100	0	100	0	100	100
13	13	13	77	23	100	100	22	100	22	92	100	0	100	100	0	100	0	100	100
14	27	37	55	7	100	100	29	100	29	100	100	0	100	100	0	100	0	100	100
15	7	44	56	1	100	86	14	100	86	100	100	0	100	100	0	100	0	100	100
16	22	48	50	2	95	91	9	100	18	91	95	5	95	57	43	32	73	27	100
17	13	24	57	9	100	92	8	100	23	100	100	0	100	100	0	100	0	100	100
18	19	73	26	1	100	100	18	100	100	100	100	0	100	100	0	100	0	100	100
10860	45	53	3	98	90	10	99	94	6	98	68	32	46	65	32	92	8	92	91

^a This is a revision of Table 1 of the Progress Report of the Committee for the Study of the Metric System in the United States, published in the Transactions of September 1959, page 257. This revision includes the analysis of the answers to 1080 questionnaires received to November 1, 1959, including the 877 which were the basis of the original Table 1.

Key to Professions

0 OTHERS (Including not identified)

1 PHYSICS

2 CHEMISTRY

3 MATHEMATICS

4 CIVIL ENGINEERING

5 ELECTRICAL ENGINEERING

6 MECHANICAL ENGINEERING

7 GEOLOGY

8 AERODYNAMICS

9 MEDICAL

10 PHARMACOLOGY

11 RESEARCH SCIENTIST

12 METALLURGY

13 BIOLOGY

14 PHOTOGRAMMETRY

15 GEOGRAPHY

16 METEOROLOGY

17 TEACHING

18 OCEANOGRAPHY

SPECIAL ANNOUNCEMENTS

• **PACIFIC SOUTHWEST REGIONAL MEETING**—Plans are advancing rapidly for the annual meeting of the Pacific Southwest Regional group to be held at the University of Southern California, February 4 and 5, 1960. Interested persons should get into touch with the new Chairman of the Regional Committee, Eugene N. Bollay (1595 East Mendocino Street, Altadena, California), or the new Secretary, W. D. Duthie (U. S. Naval Postgraduate School, Monterey, California). The Chairman for the meeting is Stanley S. Butler (2177 Hollywood Drive, Los Angeles 28, California).

• **FORTY-FIRST ANNUAL MEETING OF THE AMERICAN GEOPHYSICAL UNION TO BE HELD IN WASHINGTON, D. C., APRIL 27-30, 1960**—As announced in the September issue of the *Transactions*, the Forty-First Annual Meeting will be held in Washington, D. C., during the last days of April, 1960. Originally the dates were the 28th to 30th, inclusive, but the Section of Meteorology will start its meeting on Wednesday, the 27th; and it is anticipated that there will be a joint Space Symposium with the U. S. National Committee for IGY that will start on Wednesday, the 27th, during the meetings of the National Academy of Sciences.

Plans for the programs of the various Sections are developing rapidly. There will be general meetings of the Union as a whole, including a smoker scheduled for Thursday evening, April 28, and the Award of the William Bowie Medal and a lecture on Friday evening, April 29. General meetings of the Union and of the Sections will continue to Saturday afternoon, April 30.

Suggestions with respect to the Section meetings and to the Union as a whole are invited. Suggestions for the Union meeting should be sent to Philip H. Abelson, Chairman, Committee on Meetings, AGU, 2801 Upton Street, N.W., Washington 8, D. C. For information regarding Section meetings, consult the list of Section Secretaries and Program Chairmen below.

This announcement will also serve as an invitation for members and others to send word of plans for papers to be presented. Titles of papers with three copies of abstracts should be sent in as soon as possible and not later than February 20, 1960. (The closing date for Meteorology is January 20, 1960, and for Hydrology, January 1, 1960, see the special notes below.) Please give information concerning the time required (most papers are allowed from 10 to 20 minutes.) This information should be sent to the office of AGU at 1515 Massachusetts Avenue, N.W., Washington 5, D. C., or to the Secretary or Program Chairman of the appropriate Section as follows:

Geodesy, Buford K. Meade, U. S. Coast and Geodetic Survey, Washington 25, D. C., or Erwin Schmid (Program Chairman), U. S. Coast and Geodetic Survey, Washington 25, D. C.

Seismology, Benjamin F. Howell, Jr., Geophysical Laboratory, Mineral Sciences Building, Pennsylvania State University, University Park, Pennsylvania.

Meteorology, Woodrow C. Jacobs, 303 North Stanton Street, Lebanon, Illinois, or Fred D. White (Program Chairman), Atmospheric Sciences Program, National Science Foundation, Washington 25, D. C.

Geomagnetism and Aeronomy, J. Hugh Nelson, Geophysics Division, U. S. Coast and Geodetic Survey, Washington 25, D. C.

Oceanography, Eugene C. LaFond, Code 2235, U. S. Navy Electronics Laboratory, San Diego 52, California.

Volcanology, Geochemistry, and Petrology, Irving Friedman, 6209 Wagner Lane, Washington 16, D. C.

Hydrology, Charles C. McDonald, Water Resources Division, U. S. Geological Survey, Washington 25, D. C., or Harry E. Schwarz (Program Chairman), 315 Ladson Road, Silver Spring, Maryland.

Tectonophysics, H. Richard Gault, Department of Geology, Lehigh University, Bethlehem, Pennsylvania.

Section program planners reserve the right to close filled programs in advance of the dates indicated, so please make it a point to send word in early. Also, in some Sections, specific themes are being developed, and it is possible that if a particular paper fails to fall within one of these themes and the sessions for general papers are already closed, it may not be possible to include such papers. Abstracts of papers that are to be presented will be published in the program.

Remember that an abstract is an opportunity to bring the important results of your work to all those who see the program. The abstract should be concise and at the same time comprehensive and informative, and must not exceed 200 words (see Suggestions to Authors in the *Transactions* of April 1957, page 285, for ideas regarding abstracts). Longer abstracts will be reduced to 200 words or omitted at the editor's discretion. Please advise, in sending in the abstract, what projection equipment will be needed. Standard slide projectors (3-1/4 x 4 inches) will normally be available at the meetings, but other facilities will be provided only if especially requested well in advance. In making slides, avoid crowding and attempting to show too much on one slide. More than two or three curves on a slide tend to be confusing. Large-size lettering is essential. Complete manuscripts are not necessary but are desired and should be forwarded to the office of AGU by April 15 in order to be available to science news writers. Please indicate whether the paper is being submitted for the program only or also for con-

sideration for publication in the *Journal of Geophysical Research*.

If a paper is written in collaboration, please indicate by whom it is to be presented. Arrangements can sometimes be made with the Section Secretary or Program Chairman for the presentation of papers of authors who are unable to attend, but papers that are to be presented by title only are excluded from the program.

Make hotel or room arrangements directly with the hotel of your choice at an early date. If you fail on the first attempt, bear in mind that advance bookings that are not taken up are generally canceled by hotels about two weeks in advance. Thus a follow-up request in mid-April may bring a desired response. We are making block bookings at three hotels as follows:

Roger Smith Hotel, Pennsylvania Avenue at 18th Street, N.W.

Willard Hotel, Pennsylvania Avenue at 14th Street, N.W.

Raleigh Hotel, Pennsylvania Avenue at 12th Street, N.W.

If you write to one of the above hotels, cite the AGU block booking.

Special word regarding Meteorology—The Section of Meteorology will meet jointly with the American Meteorological Society. Fred D. White, Atmospheric Sciences Program, National Science Foundation, Washington 25, D. C., is Chairman for the Joint Meteorological Program Committee. Material relating to this program should be sent directly to him. Because of the large number of papers which are usually submitted for this meeting in Meteorology, it is planned to convene this Section one day early, beginning Wednesday, April 27. Symposia are being arranged on the following subjects: Satellite Meteorology, Wind Stress over the Sea (perhaps jointly with Oceanography), Spherics and Thunderstorm Electricity. Additional general sessions will be organized, depending on the nature of the abstracts submitted. All meteorological abstracts must be received by January 20, 1960.

Special instructions regarding Hydrology—Specific plans are being made in Hydrology to avoid the overcrowding that has characterized previous meetings. In order to afford opportunity to a large number of hydrologists to present their work, the papers are to be screened to select a number for full-length presentation. All others will be presented as five-minute summaries without discussion. This procedure has been adopted to permit more detailed discussion of subjects of broader interest and at the same time to provide a suitable forum for short presentation of other timely subjects. The summary due on January 1 may be informal, and the condensed 200-word abstract can be prepared in the ensuing month so that Program Chairman Schwarz will have these in hand by February 4. The *ad hoc* Committee will attempt to notify authors by January 25 as to

whether a particular paper is to be presented as a five-minute summary or in full. Request is made for the papers selected for full-length presentation to be available to the Program Chairman by the beginning of the meeting at the very latest.

● **SPECIAL NOTE TO ASIANS**—The American Geophysical Union has been the recipient of a fund from the Asia Foundation to aid in the support of geophysical activity in most Asian countries through memberships, subscriptions, and in other ways. This is intended to extend rather than supplant the support of scientists and institutions of Asian countries in these matters, and in this regard it is felt that the fund should be used especially for the fostering of memberships for promising young scientists and for aiding institutions by partial support of subscriptions that are not now in effect. Also, it is intended that a portion of this fund may be used to aid authors in the purchase of reprints and to enable Asian students temporarily engaged in studies in the United States to take part in meetings of the American Geophysical Union. Applications to participate in this fund should be addressed to the office of the American Geophysical Union, 1515 Massachusetts Avenue, N.W., Washington 5, D. C. The countries that are eligible for these funds under the restrictions of the Asia Foundation are: Afghanistan, Burma, Cambodia, Ceylon, Hong Kong, India, Indonesia, Japan, Korea, Laos, Malaya, Okinawa, Pakistan, Philippines, Singapore, Taiwan, Thailand, and Viet Nam.

● **TWELFTH GENERAL ASSEMBLY OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS**—Program plans for the Twelfth General Assembly are now largely developed, but in some instances it is still possible to add papers although there should be no further delay in this regard. The General Assembly will be held in Helsinki, Finland, July 25-August 6, 1960. All citizens of the United States and persons who are in residence in the United States who plan to attend as delegates, participants, or guests from the United States should get into touch with the AGU for detailed information regarding the Assembly. Circular Number 1, issued by the Finnish Organizing Committee, has been transmitted to those who have indicated plans to attend, and it is understood that Circular Number 2 will be available before the end of this year. Watch Special Announcements for additional information released by the Finnish Organising Committee from time to time. Following the meeting it is planned that there will be excursions to various parts of Finland extending from two to six days. Attention is also called to Special Announcements in previous issues of the *Transactions* relative to various facets of this meeting not here repeated.

● **NOTE REGARDING APPOINTMENTS TO UNION AND SECTION COMMITTEES**—It had been the plan to publish this list in this issue of the *Transactions*. Inasmuch as quite a number of appointments are still pending, the publication is being deferred until the March 1960 issue of the *Transactions*.



IGY BULLETIN

A monthly survey of programs and findings of the International Geophysical Year and the International Geophysical Cooperation-1959 as related primarily to United States programs

International Geophysical Cooperation-1959

The following material is based primarily on IGY World Data Center A General Report Series, No. 6, United States Program for IGC-59, which may be obtained from the Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, N. W. Washington 25, D. C., for \$1.00. Only a brief background and a few highlights of the program are given here. The above document should be consulted for a more complete picture, and for specific details on the US IGC-59 program, including names of participating institutions and locations and programs of stations.

The International Geophysical Year was scheduled to end, in a formal sense, on December 31, 1958. However, world-wide, cooperative research in geophysics during the IGY had proved to be even more valuable than the most optimistic forecasts. Accordingly, at its Fifth Assembly, held in Moscow in August 1958, the international IGY coordinating body, Comité Spécial de l'Année Géophysique Internationale (CSAGI), considered various ways and means whereby the world could continue to reap the benefits of international cooperation in geophysics.

Unanimous agreement was secured to a resolution recommending that observational and data collecting activities in the geophysical and related sciences be continued throughout 1959, on the same general plan

as during the IGY but at a level to be determined by each IGY participating committee. CSAGI recommended that the name International Geophysical Cooperation-1959 (IGC-59) be given to this extended effort.

Later in 1958 (October 2-6), the International Council of Scientific Unions (ICSU) held its triennial General Assembly in Washington, D. C. At this meeting, ICSU, the IGY parent organization, adopted a plan for IGC-59. ICSU also established a Special Committee for International Cooperation in Geophysics (SCG), consisting of the members of the CSAGI Bureau and of the World Reporters for the various IGY disciplines. Thus, the IGY on December 31, 1958, through IGC-59, entered without interruption into another phase of international, coordinated studies of our planet, in some cases at a higher level of intensity.

Following the pattern of the IGY, the National Academy of Sciences assigned to the US National Committee for IGY (Chairman, Joseph Kaplan; Executive Director, Hugh Odishaw) the responsibility for planning all phases of the US contribution to IGC-59 and for effecting the necessary international cooperation. This approach to IGC-59 was in accordance with the pattern generally followed in other countries which had participated in the IGY.

IGY scientists had recognized very early that some fields would require world-wide study and cooperation far beyond 1959. Accordingly, ICSU established Special Committees for Oceanic Research (SCOR), in August 1957, and for Antarctic Research (SCAR), in February 1958, and a Committee for Space Research (COSPAR) in October 1958.

Following here too the pattern of the IGY, the National Academy of Sciences established in this country the Committee on Oceanography (Chairman, Harrison Brown; Executive Secretary, Richard C. Vetter), the Committee on Polar Research (Chairman, Laurence M. Gould; Executive Secretary, Ross C. Peavey), and the Space Science Board (Chairman, Lloyd V. Berkner; Executive Director, Hugh Odishaw; Secretary, Ross C. Peavey), to co-operate with SCOR, SCAR, and COSPAR, respectively, in coordinating international programs in these fields.

Two other areas invited the special attention of ICSU. During the IGY, the World Warning Agency was a vital factor in the achievement of one of the most important objectives of the IGY: world-wide observation of unusual activity on the sun during a period of sunspot maximum. The notification service of the World Warning Agency proved to be of such importance to solar and upper-atmosphere studies that ICSU established a permanent International World Days Service. Called IWDS, this service is perpetuating a warning alert system similar to that of the IGY, but somewhat simplified.

Finally, ICSU assigned responsibility for a new World Magnetic Survey to the International Association for Geomagnetism and Aeronomy, part of the International Union of Geodesy and Geophysics. This survey of the earth's magnetic field is to be conducted during the next few years, which are expected to be marked by diminishing solar activity, and consequent diminution of magnetic storminess, as contrasted with

the sunspot maximum which occurred during the IGY.

Although international coordinating responsibility for programs dealing with the Antarctic, oceanography, space science, world days, and geomagnetism has been vested in groups other than SCG, all of these programs are nevertheless a part of IGC-59.

As noted, responsibility for this country's IGC-59 plans was vested by the Academy in the USNC-IGY. The United States has mounted a program in each of the scientific disciplines studied during the IGY. The US IGC-59 program consists of three parts: (i) contributed efforts from public and private institutions, including regular network operations as well as special projects of various institutions; (ii) incorporation of major programs already funded, including the 1959 Antarctic research program now underway and space science activities as developed by the operating government agencies; and (iii) a small group of projects requiring special funding by the National Science Foundation. Brief notes, including a summary tabulation (Table 1), of the programs planned in each of the IGC-59 disciplines or areas of special study follow.

Earth's Heat and Water Budget

Meteorology: Surface and upper-air meteorological observations are being made at 170 stations operated by the United States, and at 27 stations operated in co-operation with other countries. Special measurements of carbon dioxide and ozone concentrations in the atmosphere are being made at some stations, and some work is being done on oceanographic research vessels on the exchange of CO_2 between sea water and air.

In the Arctic Basin, a new floating station, Station C, was established to take the place of Station A, which had been shut down in November 1958 owing to deterioration of the ice. At Station B (on Fletcher's

TABLE 1
Summary of Programs in IGC-59 Disciplines or Areas of Study

Area of Study or Discipline	Number of Stations			Principal Objectives
	U. S.*	Cooperative**	Total	
Earth's Shape, Crust, and Composition				
Seismology	5	15	20	Further understanding of crustal structure and earthquake phenomena in the U. S., South America, and Antarctica.
Gravity	—	—	—	Fill gaps in world gravity network.
Longitudes and Latitudes	3	—	3	More accurate geodetic measurements and improved standard of time.
Earth's Heat and Water Budget				
Meteorology	170	27	197	Atmospheric circulation and geochemical studies, including carbon-dioxide, solar-radiation, and ozone measurements.
Glaciology	17	4	21	Study structure and behavior of Antarctic and Greenland ice sheets, Alaskan and West Coast glaciers, and the Arctic ice pack.
Oceanography	26	11	37	Measure currents, tides, and chemistry of the oceans.
Nuclear Radiation	148	69	217	Trace radioactivity in air, rain and snow, and ground deposits.
Upper Atmosphere, Sun, and Space				
Airglow	3	2	5	Record airglow emissions.
Aurora	26	18	44	Obtain information about auroras in relation to other upper-atmosphere phenomena.
Cosmic Rays	14	6	20	Register cosmic-ray intensity and geographic variations, using ground and airborne devices, in relation to solar events and magnetic fields.
Geomagnetism	21	7	28	Study equatorial electrojet and sub-audio signals, and their relation to magnetic storms, and continue some network studies of magnetic variations.
Ionospheric Physics	30	41	71	Extend knowledge of the ionosphere and its effects on communications.

TABLE 1—*Continued*
Summary of Programs in IGC-59 Disciplines or Areas of Study

Area of Study or Discipline	Number of Stations			Principal Objectives
	U. S.*	Cooperative**	Total	
Solar Activity	13	—	13	Continue visual and radio solar patrols, and special solar studies; observe solar eclipses of October 2.
Space Science	—	—	—	Extend knowledge of the upper atmosphere, the sun, and space by means of rockets, satellites, space probes and ground-based experiments.
World Days	—	—	—	Continue warning alert and special observation days systems of IGY.
Antarctic				
All Disciplines	2	4	6	Extend knowledge of oceans, weather and climate, and upper-atmosphere phenomena of Antarctica; make geological, geodetic, glaciological, biological, and medical observations.
Totals —	478	204	682	

*These are stations equipped and operated by U. S. personnel and located in the U. S., its territories, or possessions.

**These are stations operated on a cooperative basis with other countries and located in these countries or their possessions, or in the Antarctic. At these stations, the U. S. has supplied equipment, personnel to help install equipment and make observations, or both.

Ice Island, or T-3) special surface observations, including carbon-dioxide and solar-radiation measurements, are continuing, while at Station C a full meteorological program, including upper-air soundings, is under way.

Glaciology: Continuing Arctic glaciological work includes study of the behavior of glaciers in Southern Alaska; in cooperation with Denmark on the Greenland ice cap, movement and ice-mechanics studies, as well as tests of very deep-drilling techniques for subsequent use in the Antarctic; and, on the two floating stations, study of stratigraphy and petrofabrics of the ice pack and the heat budget of the Arctic Ocean ice-sea-atmosphere system.

Among other projects in the United States, glaciologists re-occupied for the

summer a station on Blue Glacier in the Olympic National Park to continue study of its mass and energy regimen, the mode and mechanism of flow in the ice tongue of the glacier, internal structure, and oxygen-isotope ratios.

Oceanography: Twenty-six US and 11 cooperative stations are being operated in the oceanography program. Ship operations are being conducted in both the Pacific and Atlantic, continuing profile studies in the Atlantic and study of current systems in the Pacific.

Marine geophysical studies are continuing at Drifting Station B, in the Arctic Basin, and oceanographic studies similar to those carried out at Station A during the IGY are continuing on the new drifting station, Station C.

With the cooperation of such groups as this country's Committee on Oceanography of the National Academy of Sciences, SCOR has developed definite plans for further studies of the oceans, culminating in an international cooperative investigation of the largest unknown area on earth, the 28,350,000 square-mile Indian Ocean, over a complete monsoon period in 1962-63.

Nuclear Radiation: At 148 stations operated by the United States, and at 69 stations operated in cooperation with other countries, measurements of the radioactivity of the air, of solid particles deposited on the ground, and of precipitation at the earth's surface, are being continued. This program was developed during IGY in accordance with a recommendation made by CSAGI at its Fourth Meeting, in Barcelona, in September 1956.

Upper Atmosphere, Sun, and Space

World Days: As part of the International World Days Service (IWDS), the IGY World Warning Agency (AGIWARN) operated at Fort Belvoir, Virginia, by the North Atlantic Radio Warning Service of the National Bureau of Standards, will now be known as the World Warning Agency (WWA). WWA will continue with the responsibility of issuing IGC alerts and Special World Intervals. As during the IGY, a program of Regular World Days is also under way.

Airglow: At three US stations, and at two cooperatively operated with other countries, automatic scanning photometers are in use. Launching of rockets carrying airglow observing equipment is also planned as a contribution to IGC-59.

Aurora: At 20 stations, all-sky cameras are continuing to photograph the aurora every minute. All-sky cameras are also in operation at nine stations cooperatively maintained by the United States and other countries. A new type of all-sky camera is

being used in Alaska to determine auroral heights by triangulation as a part of broad spectroscopic studies of auroral phenomena and their dependence on height. It is hoped to inaugurate in Alaska interdisciplinary observations of phenomena related to aurora, possibly in coordination with similar programs at geomagnetically opposite locations in New Zealand.

Visual, radar, and spectroscopic observations of the aurora are continuing at many locations. Special studies are planned to investigate zodiacal light for information on interplanetary media. It is planned to launch high altitude rockets at Fort Churchill, Canada, in the fall of 1959, to carry ultraviolet scanning spectrometers into the aurora. A battery of filters will also be carried to get the vertical emission profile. Altogether, there are 26 stations being operated by the United States in the aurora program for IGC-59, and 18 stations are being operated cooperatively with other nations.

Cosmic Rays: In the field of cosmic rays, 14 US and six cooperative stations are in operation. Four institutions are conducting balloon observations in the United States and Canada. At least one rocket and probably several satellite vehicles will carry cosmic-ray equipment. An air-borne neutron monitor will be used to survey the geomagnetic equator and to study latitude variations of cosmic-ray intensity. Neutron monitors, ionization chambers, and meson telescopes are being operated at many stations for continuous registration of cosmic-ray intensity.

Geomagnetism: Twenty-one stations are being operated by the United States alone, and seven are being operated in cooperation with other countries, including four in Peru with the cooperation of the Instituto Geofísico de Huancayo. The regular United States magnetic observatories are continuing to supply data to the World Data Centers during IGC-59. The special networks

established during the IGY to study the equatorial electrojet and sub-audio signals and their relationships to magnetic storms are also continuing.

Ionospheric Physics: Thirty US and 41 cooperative stations are being operated in the US IGC-59 ionospheric physics program. Measurements employing vertical soundings with modern ionosondes are taken every 15 minutes, with increased schedules on Regular World Days and during Special World Intervals. In addition to continued studies of backscatter, trans-equatorial propagation, radio noise, whistlers, and ionospheric absorption of extra-terrestrial radio signals, several groups will observe and analyze ionospheric effects upon satellite radio signals.

Solar Activity: Thirteen stations are being operated by the United States in this program, which includes continuations of optical patrols of the sun's corona, plages, flares, sunspots, and active-region magnetic fields, supplemented by solar-radio-noise patrols and radio spectroscopic observation. Expeditions to Fuerteventura, in the Canary Islands, and to French West Africa, observed the total solar eclipse of October 2, 1959. The solar-activity program also includes special rocket experiments.

Space Science: The United States space science contribution to IGC-59 is being made by several agencies through the Space Science Board. Results of appropriate launchings are expected to be made available to the World Data Centers and to COSPAR. The US space science program has been placed on as broad a basis as possible. By the end of 1959, about 75 sounding rockets and several satellites and space probes will have been launched as a contribution to IGC-59.

The satellite and space-probe contribution is largely being made by the National Aeronautics and Space Administration.

Contributions to the rocket sounding program are being made by many public and

private institutions. Emphasis is being placed upon experiments relating to atmospheric structure, electric and magnetic fields, astronomy, energetic particles, and the ionosphere. In addition, under the sponsorship of COSPAR, a World Rocket Week has been set up for the week of November 16, 1959, and the United States will participate with several rocket launchings.

Earth's Shape, Crust, and Composition

Seismology: Most of the IGY network seismological stations are continuing in operation during IGC-59. Two Benioff extensometers, or strain seismometers, are being operated in Chile and in Peru as cooperative programs; they are used to determine the strain pattern of the region. The program for studies of the structure of the earth's crust under the Andes is being extended to include a network for observations of local and regional earthquakes.

Gravity: Gravity determinations by United States groups are assisting in completion of a world network; gravity measurements at sea employing the Graf sea gravimeter and pendulum equipment are also being continued.

Longitudes and Latitudes: During IGC-59 the US Naval Observatory will continue to be the central agency for the moon position program. Photographic observations of the moon, using the dual-rate camera, and determination of astronomical longitudes and latitudes by means of the Danjon impersonal astrolabe are continuing at three stations—in Washington, D. C.; near Honolulu; and in San Diego.

Antarctica

The United States program for scientific research in the Antarctic during 1959 was developed by the Academy's Committee on Polar Research in collaboration with various federal and private agencies in the United States. The program is being carried out under the direction and coordination of

the National Science Foundation. Logistic support is furnished principally by the United States Navy. Coordination with international plans for continued cooperation in Antarctic research has been effected through the Academy's participation in the deliberations of SCAR.

The US IGC-59 program in Antarctica includes projects in aurora, cosmic rays, geomagnetism, ionospheric physics, glaciology, meteorology, and oceanography. In addition, special programs are being conducted in geology, geodesy, cartography, and biological and medical sciences.

Two United States Antarctic stations, the Byrd and Pole Stations, are staffed fully by American personnel. Hallett Station and the Scott/McMurdo complex have joint New Zealand-United States staffs. Wilkes Station and Ellsworth Station have Aus-

tralian-United States personnel and Argentine-United States personnel, respectively.

World Data Center A

World Data Center A continues as one of the three data centers set up during the IGY. World Data Center B is in the USSR, and World Data Center C is in Western Europe, Australia, and Japan.

World Data Center A was established in 11 institutions in the United States in accordance with the Academy's belief that the interests of science would best be served by housing the data in institutions with histories of scientific interest and competence in particular geophysical disciplines. Data collected during the US IGC-59 program will be collected in World Data Center A and will be exchanged with the other World Data Centers.

Rocket Measurements Through an Aurora

The following material was prepared by J. E. Jackson and J. C. Seddon of the National Aeronautics and Space Administration. The experiment described was an IGY project of the US Naval Research Laboratory, with which the authors were associated at the time.

An important phase of the IGY rocket research program at Fort Churchill, Canada, involved ionosphere studies. *Bulletin No. 20* reported on the aims, techniques, and results of three successful Aerobee-Hi rocket flights carrying experiments designed to investigate electron densities in this region of the earth's upper atmosphere.

New data were gathered on November 24, 1958, when another Aerobee-Hi instrumented to measure ionospheric electron densities was launched directly into an overhead auroral display. The Fort Churchill rocket facility is especially well located for this type of experiment (see Fig. 1).

It was possible to place the rocket into the aurora largely through the valuable advice and assistance of L. R. Davis and H. M. Caulk. The rocket instrumentation was developed by G. H. Spaid and L. A. Lohr; W. L. Joosten, Jr., and E. D. Lee operated the ground instrumentation for the CW propagation experiment (see below). Davis, Caulk, Spaid, and Lohr, now with NASA, were associated with NRL at the time; Joosten and Lee are with the New Mexico College of Agricultural and Mechanic Arts.

The 200-man team operating the Fort Churchill rocket facility consisted of military and civilian personnel of Canada and the United States. Their excellent cooperation under the able management of Lt. Col. L. G. Smith of the US Army Ordnance Corps, along with the well planned facilities of Fort Churchill, resulted in the high efficiency and flexibility of operation neces-

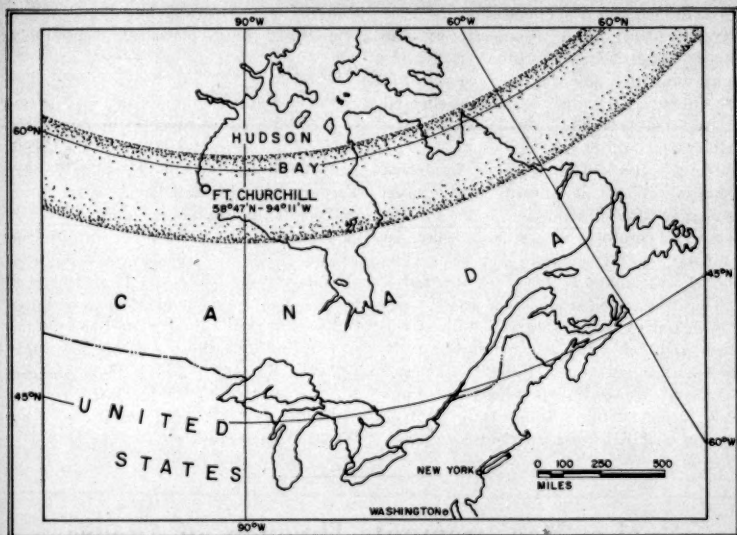


FIG. 1. Location of Fort Churchill, Canada, Rocket Research Facility, in the Heart of the Zone of Maximum Auroral Frequency.

sary for the success of this difficult experiment.

This report describes the experiment and summarizes the results.

Launching

To achieve the difficult objective of penetrating an aurora with a scientifically instrumented rocket, three conditions had to be met: (1) there had to be auroral activity with *overhead* displays; (2) clear skies were needed so that the aurora could be seen; and (3) suitable winds were necessary for the rocket launching. Since such an experiment obviously could not be scheduled for any specific night, the entire rocket range was held in continuous standby status. The rocket was kept in the tower, completely fueled and with its instrumentation ready for flight. The project scientists then waited for nature to cooperate.

Whenever circumstances appeared favorable, an alert was issued; two hours later, the entire rocket range could be ready for a launching. The launching "count-down" was held at -3 minutes if auroras were nearby and it appeared that a display might move overhead. If this did not happen within 30 minutes, the rocket pressure system was relieved and time reverted to -20 minutes. This procedure was repeated many times and on several nights, until, on November 24, 1958, the proper conditions were met and the rocket was successfully launched into an aurora.

As observed from the ground, the aurora showed rayed east-west bands of medium intensity just before rocket take-off. These deteriorated to a single weak band at the time of rocket penetration. The visual aurora disappeared completely during the rocket flight.

Experimental Techniques

A number of well-known experimental techniques were employed: (1) a two-frequency, CW (carrier-wave) radio-propagation experiment, using frequencies of 7.75 and 46.5 megacycles; (2) measurement of Faraday rotation (rotation of the plane of polarization of radio waves) at 46.5 mc; (3) analysis of irregularities in the DOVAP (Doppler-velocity-position) data; and (4) interferometer measurements at 46.5 mc (similar to Vanguard Minitrack).

The first three techniques measure, in effect, the rate of change of the total electron-density content between the rocket and the ground. If the rocket travels vertically above the ground station, and if the electron-density distribution remains unchanged with height during the flight, the density at any rocket altitude can be computed.

The fourth technique yields, under free-space (vacuum) conditions, the direction cosines of the rocket position vector. Comparison of these interferometer results with actual trajectory data reveals the errors introduced into the position-vector data by changes in the ionosphere. These errors, when separated out and analyzed, provide information about the ionospheric changes causing them.

Results

Electron densities greater than $10^6/\text{cm}^3$ were measured in the E region of the ionosphere (approximately 90–130 km) during the aurora. Both the DOVAP and Faraday data agree quite well in this respect. These large densities were also evidenced by the severe attenuation and weakening of the 7.75-mc signals. Subsequent reappearance of strong 7.75-mc signals after the aurora had dissipated indicated that the average densities along their propagation paths had dropped to values smaller than 5×10^5 electrons/cm³.

Since all the measuring techniques used

are sensitive to the total propagation path, changes in the lower ionosphere cause the higher-altitude data to be very misleading. In fact, the low-altitude variations were so great and so rapid that above a height of 140 kilometers the total electron content appeared to be decreasing during the rocket ascent, yielding what seemed to be "negative electron densities."

The rapid changes in the E region were apparent in the P'-f (vertical incidence) records taken at the time the rocket entered the E region and again, two minutes later, when the rocket entered the F2 region. The F2-region trace was almost completely obscured in the first P'-f ionogram, but clearly visible in the second. The P'-f records support the conclusion reached from the rocket data that the initially high E-region densities must have decreased substantially, and rapidly, during the rocket experiment.

The interferometer results provide similar evidence. At low altitude the interferometer data agree with the actual trajectory. In the E region, however, violent irregularities were detected in spite of the fact that the frequency used, 46.5 mc, is normally not affected by this region of the ionosphere.

Conclusions

The observations provided by the various methods used are compatible with theories that the aurora produces dense cores of ionization along the lines of force of the earth's magnetic field. Dipole antennas on the ground, set to receive signals at 46.5 and 76 megacycles (the DOVAP frequency), did not show "nulls" as the rocket rotated about its axis while passing through the aurora. Instead, they both showed erratic variations in signal intensity. Thus, when this is considered along with the large apparent irregularities in electron density noted on the 46.5-mc interferometer record and the observed average densities in excess of 10^6 el/cm³, it seems likely that the maximum densities in these auroral ionization cores

might reach a value as high as 10^7 el/cm². However, these filaments of intense ionization are spaced sufficiently far apart to allow relatively free transmission of low-frequency signals.

Electron-density profiles obtained in the complete absence of local auroral activity

(see *Bulletin No. 20*) show densities much lower than those measured in the aurora; normal winter-night densities, for example, were less than 10^4 el/cm² in the E region. Hence, it may be concluded that the large densities noted in this region during the aurora were due entirely to auroral effects.

IGY Satellite 1959 Eta

The sixth US-IGY earth satellite, 1959 Eta (Vanguard III) was launched from Cape Canaveral, Florida, at 1:20 am EDT, September 18, 1959, and went into orbit about 10 minutes later. The satellite was a project of the Goddard Space Flight Center of the National Aeronautics and Space Administration (NASA).

This was the last of the Vanguard satellites scheduled as part of the IGY program, and represents a contribution to the IGY and its extension, IGC-59. It may also be considered a contribution to the continuing international space-science effort brought into being by the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU), the parent body of IGY and IGC-59.

Aboard 1959 Eta are experiments to measure the earth's magnetic field, X-radiation from the sun, and several aspects of the space environment through which the satellite travels. For the magnetic field measurements, a new-type magnetometer capable of much greater accuracy than those in previous satellite experiments is being used.

Launching

The launching vehicle used to put 1959 Eta into orbit was, with two exceptions, essentially the same as those used to launch 1958 Beta (Vanguard I) and 1959 Alpha (Vanguard II). (See *Bulletins 11 and 22* for

further information about these earlier Vanguard satellites.)

The first two stages of the 72-foot, 22,600-pound Vanguard rocket remained the same, but the third stage was a new, more efficient, solid-propellant rocket made by Hercules Powder Company's Allegany Ballistics Laboratory. Its 10-second-longer burning time made it possible to orbit a payload weighing more than twice as much as those of previous Vanguard instrument packages. The Fiberglass, cylindrical third-stage rocket generates a thrust of about 3000 pounds.

The third-stage casing, weighing about 50 pounds, did not separate from the payload after engine burn-out, as in previous Vanguard launchings. It will remain attached to the instrument package throughout the lifetime of the satellite, providing a larger target for optical trackers. Other reasons for leaving the third stage attached were to minimize precession, or wobbling, of the satellite during its earlier orbits, and to prevent collision between the third stage and the satellite in the event that the rocket engine had continued to burn, or had "coughed," after release of the satellite.

Satellite Characteristics

The satellite is a 50-pound, 20-inch-diameter sphere with a 26-inch, conical tube (housing the magnetometer sensor) protruding from its top. The tube ranges from $2\frac{1}{2}$ to 6 inches in diameter. The main part

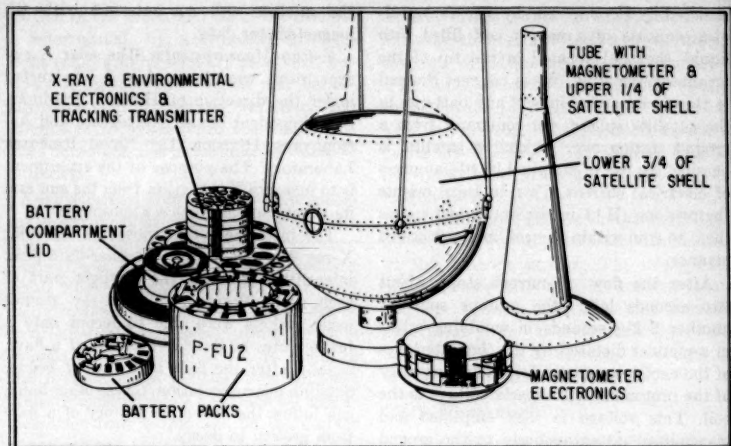


Fig. 2. Shell and Instrumentation of 1959 Eta. The ionization chamber is located behind the circular window at left-center of the satellite shell; the linear strip at right-center of the shell is an erosion gauge. Adapted from NASA photograph.

of the satellite shell and internal structure is magnesium. The magnetometer tube is fabricated of glass fibers and phenolic resins, and the forward part of the satellite sphere, to which the tube is attached, is also Fiberglass.

Four antennas, situated 90° apart, extend outward in the equatorial plane of the satellite. These were folded upward prior to release of the satellite, but sprang outward when the nose cone was released.

Experiments and Instrumentation

The three experiments in 1959 Eta, one involving several types of measurements, constitute the greatest variety of studies included in any single US-IGY satellite thus far. (See Figure 2). NASA's project officer for the 1959 Eta experimental payload is R. W. Stroup, Senior Project Coordinator, Satellite Applications Systems Division.

Magnetic Field Measurements: The magnetometer experiment is directed by J. P.

Heppner of NASA's Space Sciences Division. With its day-to-day readings from varying altitudes and geographic locations, this experiment will help to chart the earth's magnetic field in space. These measurements are of special importance to future manned space explorations since the charts made from this and similar magnetic-field studies in the future will indicate the best routes to avoid regions of intense radiation trapped in the magnetic field.

The experiment is also providing data that will aid in a better understanding of magnetic storms—solar-related disturbances of the magnetic field which render virtually useless tools relying on the magnetic field, such as the magnetic compass and surveying and navigational instrumentation. The magnetic data will also supply further information about electric currents in the ionosphere, hitherto investigated directly only at a few isolated locations and for short time intervals with rockets.

The magnetometer, designed and con-

structed by Heppner and by Varian Associates, consists of a copper coil filled with liquid (hexane) located in the tip of the magnetometer tube. Wires connect the coil to the electronic equipment and batteries in the satellite sphere. On command from a ground station over which the satellite is passing, the coil is energized by $6\frac{1}{2}$ amperes of electrical current. This, in turn, orients the protons (H^+) in the liquid and causes them to spin within the coil in a prescribed manner.

After the flow of current stops, about two seconds later, the protons spin for another 2-2½ seconds in wobbling orbits in a manner dictated by the characteristics of the earth's magnetic field. The frequency of the proton motion imparts voltage to the coil. This voltage is then amplified and transmitted instantaneously to the ground receiver, where it is taped. Simultaneously, a reading is made at the ground magnetometer, with which each of the interrogating stations is equipped.

Analysis and comparison of the satellite and ground readings will supply much information about the shape, intensity, and variations of the earth's magnetic field. Besides providing additional calibrations for determination of the main geomagnetic field, the simultaneous readings at ground stations will help locate and define ionospheric currents, since measurements both above and below the ionosphere are needed to delineate such currents.

The satellite is interrogated about 50 times a day for magnetic data, or about twice on each pass over a tracking station. The length of the command signal and of the telemetered data varies according to altitude, battery voltage, and satellite temperature, which may range from $-10^{\circ}C$ to $50^{\circ}C$ (14° to $122^{\circ}F$). The satellite is in range of a tracking station for about eight minutes on each pass. It is expected that the magnetometer tube will precede the sphere in flight during the initial orbits, but, in any event, later tumbling or wobbling of

the satellite will not interfere with the magnetometer data.

X-Ray Measurements: The solar X-ray experiment was designed and constructed under the direction of Herbert Friedman, Superintendent of the Atmosphere and Astrophysics Division, US Naval Research Laboratory. The purpose of the experiment is to measure X-radiation from the sun and its effects on the earth's atmosphere.

The instrumentation measures the solar X-ray flux and records the solar-flare peak intensity throughout the daylight part of each orbit. Previous solar X-ray studies using rockets were able to record only a few minutes of the development of a flare, usually after the flare had already begun. Satellite instrumentation, on the other hand, can follow the entire life history of a flare from growth to decay.

Two identical ionization chambers sensitive to wavelengths of 1-10 Angstroms (X-rays in this range are produced in solar flares) are the main components of the X-ray instrumentation. The ionization chambers, which record the ionic charge produced by the X-rays, are oriented about 120° apart on the satellite's equatorial plane. The maximum signal occurs when an ion-chamber tube "looks" in the direction of the sun.

The X-ray instrumentation also includes an electrometer circuit for amplifying currents generated in the ionization chambers and a peak-reading memory device. The memory device retains the maximum X-ray signal received during an orbit. This memory core is the controlling element in an audio oscillator that modulates (alters the frequency or amplitude of) the Minitrack signal with the ion-chamber signals. Actually, two cores are used in an orbital switching arrangement: while the core containing the maximum signal from the preceding orbit is modulating the transmitter, the second core is storing data from the current orbit. The roles are reversed as the satellite passes from the night to the day

portion of the orbit, and when the satellite is interrogated, by a switching arrangement using a light-sensitive solar cell. Analysis of the modulated signal provides information on the intensity variations and energies of X-rays entering the chamber. A third core transmits instantaneous values of radiation.

Environmental Measurements: The space-environment experiment is directed by Herman E. La Gow, Head of the Planetary Atmospheres Branch at NASA's Goddard Space Flight Center. This experiment will help provide a more accurate knowledge of environmental conditions in space, which is essential to the design of future satellites and manned space vehicles. Four different kinds of measurements are made by instrumentation both within and on the surface of the sphere.

Two thermistors (tiny thermometers) mounted on the inside wall of the satellite provide a time history of the average shell temperature and of temperature fluctuations throughout the orbit. A third thermistor measures the internal temperature of the solar X-ray instrument compartment. Two hermetically sealed pressure zones girdling the interior walls of the satellite are designed to record the impact of micrometeorites large enough to pierce the satellite shell. The zones, which cover about 20% of the area of the shell, have been drained of enough air to make them partial vacuums, each at a different pressure. A differential pressure gauge is located between the zones and connected to both of them. If either zone is punctured, data indicating which zone it was is telemetered as a change in length of one of the telemeter channels.

Erosion of the satellite shell through bombardment by dust, micrometeorites, ions, molecules, and atoms is recorded by three chromium-strip erosion gauges on the satellite surface and by a photosensitive detector. Electrical resistances of the gauges change as their surfaces are changed by

erosion. The photosensitive detector, a cadmium-sulphide cell protected by an opaque covering of Mylar plastic and deposited aluminum, also shows a resistance change as the covering is eroded or penetrated. As with the pressure zones, erosion measurements are telemetered as channel lengths, but in this case permitting estimates of the erosion rates.

In addition, four barium-titanate-type microphones record micrometeorite impacts on the sphere's surface. The microphone output is amplified, shaped, and fed into a magnetic counter unit. This unit provides continuously, in three-decimal digits, the cumulative count of impacts. It counts up to 1000 and then resets to zero.

Radio Equipment

The satellite carries two radio transmitters. One transmits continuously a 108.00-megacycle tracking signal modulated by the X-ray and environmental data, except during the brief periods of operation of the other transmitter when this modulation ceases temporarily. The second transmitter, when interrogated by a ground station, sends stored magnetometer data at 108.03 megacycles. The power level of the 108.00-megacycle transmitter is about 30 milliwatts and that of the 108.03-megacycle transmitter is about 80 milliwatts. It is expected that the batteries powering the satellite instrumentation will have a lifetime of about three months.

Tracking

Satellite 1959 Eta is being tracked by 9 NASA Minitrack stations. These are located at Blossom Point, Maryland; Santiago, Chile; Antofagasta, Chile; Lima, Peru; Quito, Ecuador; Antiqua Island, B.W.I.; San Diego, California; Esselen Park, South Africa; and Woomera, Australia. All 9 stations received good signals from the satellite during the first day after launch.

Through the Amateur Radio Relay League, amateur radio operators were asked

to record as many 108-megacycle transmissions as possible during the first four weeks of the satellite's lifetime. It was hoped that this would broaden the possibility of catching a solar flare at the right moment or of catching parts of a flare that might be missed by the NASA ground stations.

The satellite is being tracked optically by the widespread network of Moonwatch teams and with Baker-Nunn tracking cameras at stations set up as part of the IGY program. (See *Bulletin No. 12* for a listing of these stations.) The optical tracking, under a grant from NASA, is supervised by the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts.

The first Moonwatch sighting of 1959 Eta was made at 0250 UT, September 19, at China Lake, California, by the team led by Carroll L. Evans, Jr. During the first three

days after launch, a total of 11 Moonwatch teams observed the satellite. The Tokyo Baker-Nunn station photographed 1959 Eta at 0931 UT, September 18. This first Baker-Nunn photograph of the satellite was made only 4 hours and 11 minutes after launch time. Three more Baker-Nunn stations, one in Spain and two in the U. S., photographed the satellite a total of 10 times in its first two days in orbit.

Orbital Data

The following approximate orbital information for 1959 Eta was announced on September 18, after the satellite had circled the earth several times: perigee, 320 statute miles; apogee, 2329 statute miles; period, 130 minutes; inclination of orbit to equator, 33° ; velocity at perigee, 18,567 statute miles per hour; and velocity at apogee, 12,631 statute miles per hour.

WWA Decisions and Geomagnetic Disturbances February 1—June 30, 1959

This report on results of the World Days Program being carried out under the International Geophysical Cooperation—1959 covers the period February 1–June 30, 1959. (See *Bulletin No. 23* for a report on the previous four months, the concluding period of the IGY program, and on the organization of the IGC-59 World Days Program.)

In February and March, geomagnetic disturbances generally were minor in intensity, and were associated with mild terrestrial effects. A significant exception was the geomagnetic storm which began on March 26. Although not as severe as some storms which occurred during the IGY period, it was accompanied by a longer period of disturbed radio quality— $3\frac{1}{2}$ days—than has been associated with any single geomagnetic disturbance in several years.

Ten geomagnetic disturbances occurred during the April–June quarter. Special

World Intervals were declared by the World Warning Agency (WWA) to accompany the two most severe storms, those of April 9 and May 11, and the disturbance of June 11, which, although minor, was unusual because it apparently was associated with solar activity on a part of the sun that was not visible at the time the activity occurred.

Seventeen disturbed 6-hour radio-quality figures were recorded during the ten magnetic disturbances of the quarter. Two whole-day radio disturbances were noted, accompanying the magnetic storms of May 11 and May 15.

A list of geomagnetic disturbances, Special World Intervals (SWI), world-wide geophysical Alerts, and major solar flares (those which at least one observatory evaluates as 3 or 3+ in importance) for the period February 1–June 30, 1959, follows:

Feb	2	1017	Class 3 flare	13	0831	Class 3 flare; sudden short-wave fadeout
		1816	Class 3 flare; sudden short-wave fadeout and gradual recovery	23	1036	Magnetic storm begins
	9	0810	Class 3 flare	24	17xx	Magnetic storm ends
	10	0817	Class 3 flare	May 4	2022	Minor magnetic storm begins
	11	0756	Minor magnetic storm begins	5	16xx	Minor magnetic storm ends
		xxxx	World-wide geophysical Alert issued		0605	Class 3 flare; sudden short-wave fadeout
	12	xxxx	Alert ends	7	2130	Minor magnetic storm begins
		2300	Class 3 flare; slow short-wave fadeout and gradual recovery	8	12xx	Minor magnetic storm ends
				10	2055	Class 3 flare; slow short-wave fadeout and gradual recovery
	13	01xx	Minor magnetic storm ends		2310	Class 3 flare
	14	1143	Minor magnetic storm begins	11	2010	Class 3 flare; sudden short-wave fadeout
	17	12xx	Minor magnetic storm ends		2330	Severe magnetic storm begins
	19	2035	Class 3 flare; slow short-wave fadeout	12	xxxx	Alert issued
	25	0215	Magnetic storm begins		xxxx	SWI starts
		xxxx	Alert issued, advising of storm and expected auroras	13	01xx	Severe magnetic storm ends
	26	xxxx	Alert ends		xxxx	Alert ends
Mar	4	00xx	Magnetic storm ends		xxxx	SWI finishes
	19	1038	Class 3 flare; sudden short-wave fadeout and gradual recovery	15	11xx	Magnetic storm begins
	21	0917	Class 3 flare; sudden short-wave fadeout	16	xxxx	Alert issued
	24	0709	Class 3 flare; slow short-wave fadeout		12xx	Magnetic storm ends
		0958	Class 3 flare; sudden short-wave fadeout	17	xxxx	Alert ends
	26	0842	Severe magnetic storm begins; prolonged period of disturbed radio quality		0523	Class 3 flare; sudden short-wave fadeout and gradual recovery
		xxxx	Alert issued, advising of storm and expected auroras	24	0540	Magnetic storm begins
	28	2114	Class 3 flare; sudden short-wave fadeout		xxxx	Alert issued
		xxxx	Alert ends	25	12xx	Magnetic storm ends
	30	14xx	Severe magnetic storm ends		xxxx	Alert ends
Apr	4	0646	Class 3 flare	June 2	1810	Class 3 flare; sudden short-wave fadeout and gradual recovery
	5	2316	Class 3 flare; sudden short-wave fadeout and gradual recovery	6	0945	Class 3 flare
	8	0916	Class 3 flare; sudden short-wave fadeout	11	0613	Class 3 flare
	9	1827	Magnetic storm begins		0910	Minor magnetic storm begins (associated with unusual solar activity)
	10	xxxx	Alert issued		1902	Class 3 flare
		xxxx	SWI starts		xxxx	Alert issued
		23xx	Magnetic storm ends		xxxx	SWI starts
	11	xxxx	Alert ends		22xx	Minor magnetic storm ends
		xxxx	SWI finishes	12	0821	Class 3 flare
					xxxx	Alert ends
					xxxx	SWI finishes
				16	0618	Class 3 flare; sudden short-wave fadeout and gradual recovery
				17	1450	Class 3 flare
				18	1130	Class 3 flare

IGY Bibliographic Notes

This is the fifteenth of a series of bibliographic notes on IGY and IGC-1959 programs and findings. In this issue, the Notes are devoted entirely to the status of the IGY Annals.

Eleven volumes of the *Annals of the International Geophysical Year* have been published or are in preparation, and future volumes are planned. The *Annals* will constitute a central record of IGY activity,

formal proceedings, technical manuals and results. They are published by the Pergamon Press, Ltd., 122 East 55th Street, New York 22, N. Y., and 4 & 5 Fitzroy Square, London, W. 1.

Vol. I, History of the IGY, 446 pp., 1959.

Part I, "The First International Polar Year," pp. 1-203.

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Part III, "The Inception and Development of the International Geophysical Year," p. 383-446.

Vol. IIA, Reports of CSAGI Meetings, 395 pp., 1959.

Part I, "The First Meeting of the CSAGI," pp. 1-76.

Part II, "The Second Meeting of the CSAGI," pp. 77-202.

Part III, "The Third Meeting of the CSAGI," pp. 203-296.

Part IV, "The Fourth Meeting of the CSAGI," pp. 297-395.

Vol. IIB, Reports of the CSAGI Meetings (in press).

Vol. III, IGY Instruction Manual—The Ionosphere, 381 pp., 1957.

Part I, "Ionospheric Vertical Soundings," pp. 1-167.

Part II, "The Measurement of Ionospheric Absorption," pp. 173-226.

Part III, "The Measurement of Ionospheric Drifts," pp. 231-287.

Part IV, "Miscellaneous Radio Measurement," pp. 293-381.

Vol. IV, IGY Instruction Manual, 393 pp., 1957.

Part I, "Techniques for Radioactivity Measurements," pp. 7-17.

Part II, "Aurora and Airglow," pp. 23-138.

Part III, "Longitudes and Latitudes," pp. 143-201.

Part IV, "Geomagnetism—Part I," pp. 207-245.

Part V, "Geomagnetism—Part II," pp. 251-329.

Part VI, "Seismology," pp. 335-344.

Part VII, "Cosmic Radiation," pp. 349-393.

Vol. V, IGY Instruction Manual, 466 pp., 1958.

Part I, "Ozone," pp. 5-114.

Part II, "Auroral Photography by All-Sky Camera," pp. 121-151.

Part III, "Antarctic Radio Communications Manual," pp. 157-244.

Part IV, "Solar Activity," pp. 249-301.

Part V, "Radioactive Fall-Out Data and Their Interpretation," pp. 307-362.

Part VI, "Radiation Instruments and Measurements," pp. 367-466.

Vol. VI, Rockets and Satellites, 508 pp., 1958.

Part I, "Introduction," pp. 1-10.

Part II, "The IGY Rocket Program," pp. 11-114.

Part III, "The IGY Earth Satellite Program," pp. 115-452.

Part IV, "CSAGI Conference Resolutions and Data Guide," pp. 453-473.

Part V, "Special Bibliography," pp. 474-475. (Annexes, pp. 475-508).

Vol. VII, IGY Instruction Manual, 388 pp., 1959.

Part I, "World Days and Communications," pp. 1-138.

Part II, "CSAGI Guide to IGY World Data Centers," pp. 139-373.

Part III, "Arctic Communications," pp. 379-388.

Vol. VIII, Geographical Distribution of the International Geophysical Year Stations, 304 pp., 1959.

Vol. IX, Programmes of IGY Participating Committees (in press).

Vol. X, Fifth Meeting of the CSAGI (Moscow) (in preparation).

Vol. XI, First Results of IGY Rocket and Satellite Research (in preparation).



IGY BULLETIN

A monthly survey of programs and findings of the International Geophysical Year and the International Geophysical Cooperation—1959 as related primarily to United States programs.

NBS Radio, Ionosphere, and Airglow Observations During IGY

The following report is adapted from a more detailed treatment by David M. Gates which appeared in the Journal of Research of the National Bureau of Standards—D. Radio Propagation, July-August 1959.

The International Geophysical Year was selected to coincide with a period of maximum solar activity, which was likely to produce vast and diverse effects on the atmosphere of the earth. Since the ionosphere is primarily produced by solar irradiation of the upper atmosphere it was anticipated that the IGY period would be particularly suitable for a worldwide ionospheric physics observational program. For this purpose the regular observational program of the Central Radio Propagation Laboratory of the National Bureau of Standards in Boulder, Colorado, was enlarged and special experiments were set up. These experiments ranged from the large synoptic network of ionospheric vertical incidence sounding stations to equatorial forward scatter, sporadic-E, radio noise, night airglow, and observations of satellite transmissions through the ionosphere.

During the IGY period a close watch on the sun was kept by solar patrols distributed throughout the world utilizing visual,

optical, photographic, photometric, and radio techniques.

The IGY World Warning Agency headed by R. C. Moore at the NBS station at Fort Belvoir, Virginia, was designated to process and filter data from this global network of patrol stations, to maintain a running account of the "state of the sun," and to alert the scientists of the world to periods of unusual solar activity. At times, during those Alerts, Special World Intervals were declared, thereby accelerating scientific observations in solar and upper atmosphere IGY research programs throughout the world. Before the IGY it had been thought that the forecast of two major storms during the entire IGY period would represent adequate success. Actually, about two-thirds of the severe geomagnetic disturbances during IGY were predicted.

IGY Ionospheric Vertical Sounding Observations

During the International Geophysical Year a large network of vertical incidence ionospheric sounding stations (about 150) was placed in operation throughout the world. Since the vertical incidence pulse technique is one of the most reliable methods for obtaining a measure of the electron

density and the electron density profile of the ionosphere, it was important to establish stations of this nature at as many strategic locations as possible. Prior to the IGY the National Bureau of Standards operated 20 stations throughout the world, while during the IGY it operated directly or cooperated with other agencies in the operation of 34 stations. All stations were on a 15-minute basic-sounding schedule. Much of the reduction of the data was done at the stations, but all data sent to Boulder on a monthly or bimonthly basis were reviewed in order to assure smooth and consistent operation of the program. The vertical incidence program at the National Bureau of Standards has been under the direction of A. H. Shapley, R. W. Knecht, and H. G. Sellery.

Equatorial Close-Spaced Chain: Interesting results have come from the ionospheric soundings from the equatorial close-spaced chain of stations in South America.

These stations were located at Talara, Chiclayo, Chimbote, Huancayo, and La Paz. In Figure 1 the variation of electron density at fixed heights is shown for the 24-hour period at Huancayo. These curves are typical of the other four stations as well. The sharp increase at sunrise in the electron density should be noted as well as the fact that the intermediate levels attain a maximum electron density earlier than the higher levels of the ionosphere. Particularly notable is the abrupt rise in height of the electron density at sunset, an effect considerably larger than expected from straight recombination alone.

Equatorial sporadic E ("clouds" or patches of increased ionization in the E region) occurs during most daylight hours throughout the year at stations near the equator. It appears on the ionogram as a diffuse trace often extending 20 km or more in height and seldom blanketing the F region echoes. Figure 2 shows the percent-

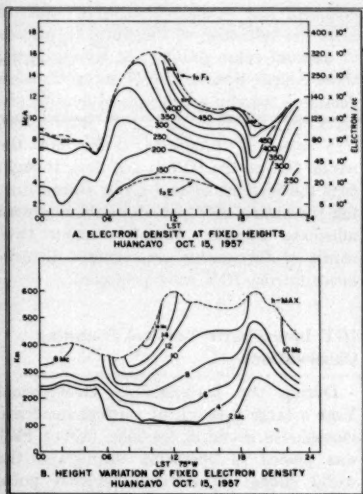


Fig. 1. Height-Density Relationships at Huancayo, Peru.

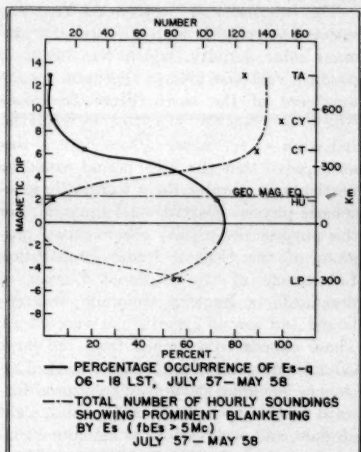


Fig. 2. Occurrence of Equatorial Sporadic E as a Function of Magnetic Dip of Station. TA = Talara, CY = Chiclayo, CT = Chimbote, HU = Huancayo, and LP = La Paz.

age occurrence of equatorial sporadic E as a function of the magnetic dip of the station. Eleven months of data (July 1957 through May 1958) were averaged to obtain the percentages for Talara, Chiclayo, Chimbote, and Huancayo; however, only one month of data was available for La Paz. From the curve it is clear that this form of sporadic E is a very distinctive equatorial phenomenon, and that it occurs with a frequency greater than 35 percent only within a belt spread about 5.5° to either side of the geomagnetic equator and has dropped to a frequency of only 5 percent by 8° from the geomagnetic equator. Although earlier workers had suggested a somewhat wider belt for equatorial sporadic E, recent IGY experiments on the earth's magnetic field in the vicinity of the geomagnetic equator by S. E. Forbush, as recently reported by H. Odishaw, give a similar width to the equatorial electrojet.

Although the equatorial sporadic E persisted throughout most days of the year, occasionally it would disappear suddenly for periods of minutes to hours in the early afternoon. S. Matsushita has established a definite lunar dependence for this effect, which suggested that a similar relationship might hold true for the time of first appearance of equatorial sporadic E, since these times varied from as early as 0600 to as late as 1000. In contrast, the late afternoon disappearance occurred regularly between 1730 and 1830. In order to test this hypothesis the data for Huancayo from May 1957 to April 1958 were divided into the three seasons (equinox and June and December solstices). Three-day running means of the times of first appearance were computed and plotted against the lunar phase as shown in Figure 3. A lunar correlation is clearly evident in the equinoctial and December-solstice curves with equatorial sporadic E appearing earlier in the morning on days of new and full moon. The data for the June solstice do not suggest quite as strong a lunar control; however, as more

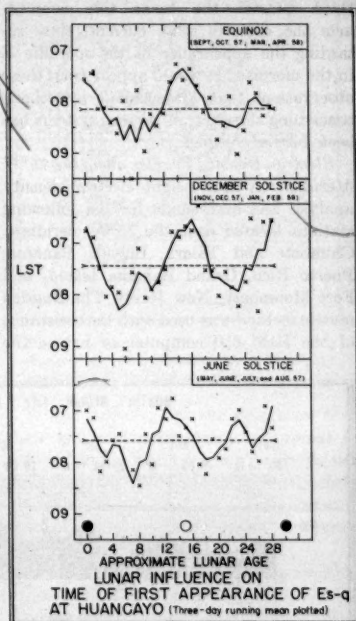


Fig. 3. Lunar Influence on Appearance of Equatorial Sporadic E.

data become available the scatter of the points may be reduced. Matsushita had explained the lunar effect for the midday disappearance in terms of ionospheric electric currents. He assumed that the equatorial sporadic E was caused by the vertical drifting of electrons in the eastward-flowing electric current and that the lunar tides induce a westward-flowing counter-current which reduces the strength of the sporadic E. Pursuing these arguments further, Knecht of the Central Radio Propagation Laboratory points out that during the new and full moon the lunar-induced current adds an easterly flow to the already established solar-induced easterly during the early morning hours; during the first and

third quarter the lunar tide counteracts the easterly solar current, thus retarding the appearance of the sporadic E in the morning. It would appear from these observations that Matsushita's hypothesis concerning the electron-current systems has been further verified.

Electron Density Profiles along the 75°W Meridian: A true height electron density analysis has been made for the following stations located near the 75°W meridian: Chimbote and Talara, Bogota, Panama, Puerto Rico, Grand Bahama Island, and Fort Monmouth, New Jersey. The Budden matrix method was used with the assistance of the IBM 650 computer to reduce the

ionogram data. Another computer program was used to interpolate the values of electron density at fixed heights, compute the height of the maximum and integrate the electron density up to h_{max} . This research was carried out at NBS by J. W. Wright and G. H. Stonehocker.

Hourly ionograms from the seven stations were reduced to give true heights of reflection at intervals of 0.2 mc from 1.8 mc to f_oF_2 (critical frequency of the F2 layer, i.e., the frequency at which total reflection occurs). Several usual ionospheric features show up, but, in addition, an increase in electron density occurs over Bogota during the late evening hours and a

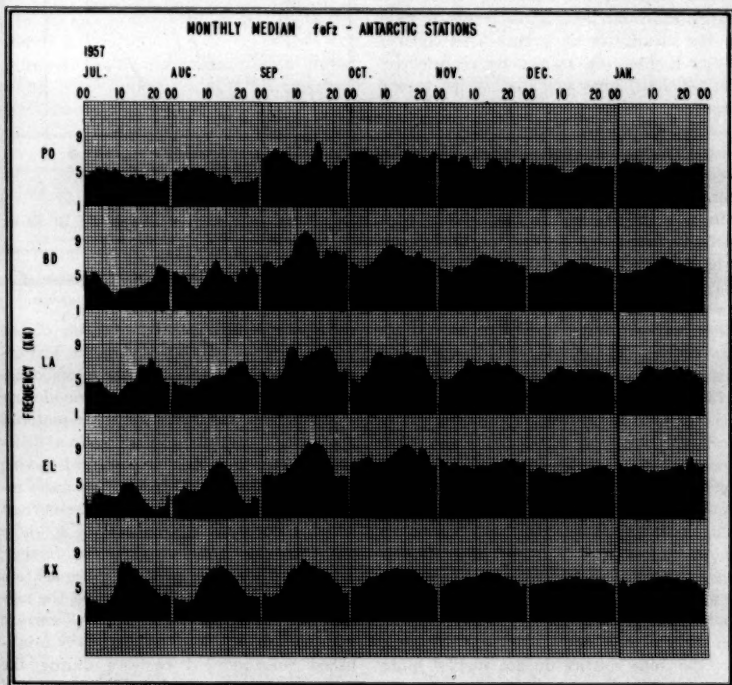


Fig. 4. Results of Vertical Incidence Soundings at Five US-IGY Antarctic Stations.

bulge develops in the ionosphere over the equator. This bulge may be the result of some form of tidal action but at the moment it is not fully understood.

Vertical Incidence Soundings from Antarctica: During the IGY the first sizeable network of ionospheric vertical incidence stations on the Antarctic continent was established. Of approximately a dozen stations, five were operated by the U.S. at the Pole, Byrd, Little America, Ellsworth, and Wilkes IGY stations. The data reported here represent the first from high-latitude southern stations and the first ever obtained at either the North or South Pole. Prior to making these observations there was considerable question concerning the state of the ionosphere above the South Pole, whether the ionosphere could exist throughout the 6-month period of darkness, whether diurnal variations existed in the polar winter ionosphere, and the nature of the f_oF_2 variations over the Antarctic continent. The present data, representing the period June 1957 to May 1958, definitely supply the answers to some of these questions.

In Figure 4 are shown, for five of the Antarctic stations, the monthly median values of f_oF_2 plotted against time of day for each hour. For the Wilkes and Ellsworth Stations, the normal temperate latitude behavior is seen with the diurnal variation reaching a maximum around midday. For the Little America and the Byrd stations the maximum is reached during the evening hours and for the Pole there appears to be a weak diurnal variation with the maximum occurring in the early morning hours. It is curious indeed that the ionosphere over the Pole in July has minimum f_oF_2 values which are greater than those over any other station. This is particularly surprising since throughout July the atmosphere above the Pole is not illuminated below an altitude of about 450 km. As expected, the summertime (December) f_oF_2 values exhibit relatively little diurnal variation.

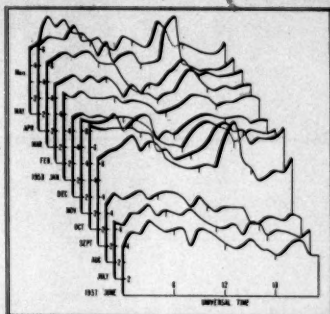


Fig. 5. Ionospheric Profiles at South Pole Station. Monthly median values of f_oF_2 for each hour of the day are shown.

Winter soundings at the Pole show that there is considerable ionization present as low as 250 km while the sun's rays do not strike below 450 km for July. Particularly noteworthy in the summer is the constancy throughout the day of the critical frequency for E, F₁, and F₂.

A more detailed picture of the monthly median values of f_oF_2 for each hour of the day for the period June 1957 through May 1958 is shown in Figure 5. The winter months (June, July, August) have the lowest f_oF_2 values and appear to have a 24-hour wave, whereas the equinox and summer values are higher and exhibit a 12-hour variation. A harmonic analysis of the monthly median values of f_oF_2 for these data is shown in Figure 6 for the 24-, 12-, 8- and 6-hour components. The 24-hour component shows the winter values occurring at 0600 UT to be 90° out of phase with the summer values at approximately 0000 UT, thus suggesting that the F-layer density in the darkened part tends to reach a maximum during those hours when the auroral zone has the maximum amount of sunlight for that time of the year. The 12-hour wave appears at 0400 and 1600 UT and the 8-hour wave at 0730, 1530, and 2330 UT. The 6-hour wave appears indefinite.

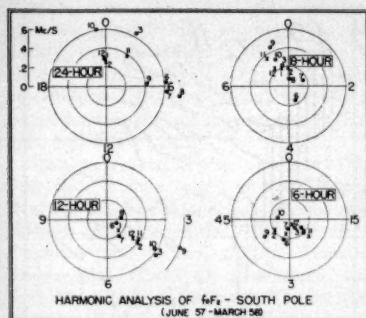


Fig. 6. Harmonic Analysis of South Pole Data from Fig. 5.

Although the analysis is still in progress it would appear that a significant diurnal variation occurs in the f_oF_1 and f_oE during the polar summer. The principal wave seems to have a 24-hour period, showing a maximum at 2200 for f_oF_1 and at 1300 for f_oE . Even more striking is the summertime, daylight behavior of f_oF_2 , f_oF_1 , and f_oE monthly mean values for the Pole Station when plotted against Zurich sunspot number as shown in Figure 7. It would appear from these results that over the Pole the F_2 region of the ionosphere becomes weaker, the E region strengthens, and the F_1 region is relatively insensitive to increased solar activity. This occurs at the time of the year when the polar ionosphere is completely and continuously illuminated. By comparison, it is well known that at stations throughout the world, the critical frequency for each region of the ionosphere increases with increasing sunspot number, since the increased solar activity produces an increase in ionizing radiation. Certainly it appears that the data from the Pole Station are unique in many respects. They raise several questions which unfortunately may not be answered until a much more detailed analysis is carried out. In certain instances further data will need to be obtained from the Pole Station and careful

comparison made with data from other Antarctic stations. Fortunately, the scientific observational program is continuing in Antarctica during 1959, although at a reduced level.

VHF Equatorial Forward Scatter Experiments

Before IGY, experiments in VHF ionospheric forward scatter had been primarily conducted in north temperate latitudes and in the auroral zone, and not in the vicinity of the magnetic equator, where the ionosphere behaves differently and in a manner little understood. In this region are exhibited such phenomena as equatorial sporadic E, equatorial spread F, and a strong daytime current-system girdling the earth at the 100-km level, known as the "equatorial electrojet." Amateur radio communications spanning the magnetic equator (e.g., between Buenos Aires and Mexico City) have been sustained on the 6-meter band (near 50 mc) during evening hours of equinoctial periods at times of sunspot maximum, sug-

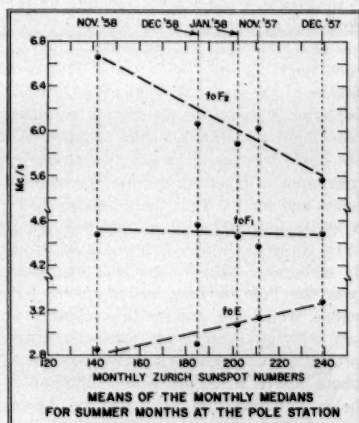


Fig. 7. Effect of Solar Activity on Ionosphere at South Pole.

gesting unusual ionospheric conditions in the equatorial zone.

To provide a systematic study of ionospheric irregularities and other effects which might support ionospheric propagation at 50 mc across the magnetic equator, an IGY experiment was set up in South America. A basic E-scatter circuit was installed between Arequipa and Trujillo, Peru, while the long-distance circuit between Antofagasta, Chile, and Guayaquil, Ecuador, was operated to observe scattering associated with effects in the lower F region. These circuits, centered on the magnetic equator at Huancayo, recorded over a 1-year period so as to enable the study of seasonal and diurnal variations as well as more rapid changes in the equatorial ionosphere. R. Cohen and K. L. Bowles were the project leaders. (See Figure 8.)

The basic equipment for the forward scatter experiments consisted of large rhombic antennas, high-powered (3 kw or 20 kw interchangeable) transmitters, and sensitive narrow-band receivers. The transmitting stations at Antofagasta, Chile, (49.960 mc), and Arequipa, Peru, (49.920 mc) and the receiving stations at Huancayo, Peru, Trujillo, Peru, and Guayaquil, Ecuador, employed 1000-foot rhombic antennas directed along the several great-circle paths. One transmitting station, Huancayo, Peru, (49.880 mc), and the two receiving stations at Clorinda, Argentina, and Sao Paulo, Brazil, utilized stacked pairs of 5-element Yagi antennas. The Huancayo installation also had a small low-powered 100-w transmitter feeding a Yagi antenna directed toward Guayaquil. This circuit is intended for detection of the sporadic E between Huancayo and Guayaquil.

Two east-west circuits were installed along the 20° isocline, to receive signals from Antofagasta at Clorinda, Argentina, via the E region and at Sao Paulo, Brazil, via the F region. These circuits were installed to compare equatorial east-west propagation, insofar as possible, with the north-south propagation, as well as to check

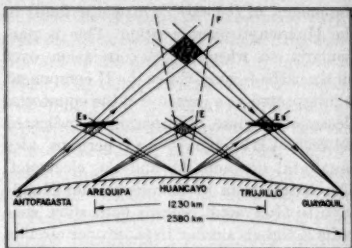


Fig. 8. Forward Scatter Circuits from Huancayo. F = F layer; E = E layer; and E_s = sporadic E .

on the southern range of latitude over which equatorial effects are encountered. The presence of transmitters and receivers appropriately spaced permitted the reception of signals at Huancayo from Antofagasta, at Trujillo from Antofagasta, and at Guayaquil from Arequipa, in addition to the basic circuits previously mentioned and the Huancayo-Guayaquil circuit. Thus there are three symmetrical E-scatter paths, as well as two asymmetrical paths, which permit the simultaneous observation of E-region effects at various latitudes. Ionospheric effects in this extensive region near the magnetic equator are particularly sensitive to latitude. Further details concerning the same ionospheric regions are provided by the records from the close-spaced chain of ionospheric sounders along the west coast of South America.

Over the two paths, Antofagasta to Guayaquil and Arequipa to Trujillo, the short-term daytime variations in the signal intensity appear to correlate very closely. Indeed, over all six circuits, the daytime signal traces appear to correlate reasonably well while nighttime correlations are poor. Comparisons with the vertical incidence soundings at Huancayo suggest that these daytime signals result from scattering by equatorial sporadic E. A close correlation exists, during certain periods studied, between the signal over the Arequipa to Trujillo path and the H component (horizontal

component of the earth's magnetic field) of the Huancayo magnetogram. This is particularly so when signal correlation over all six paths is good. Since the H component is interpreted as a measure of the equatorial electrojet, a close relationship is indicated between VHF signals, and perhaps also equatorial sporadic E, and the electrojet. The Antofagasta to Huancayo and Huancayo to Guayaquil records both show sporadic E signals similar to those over circuits in middle latitudes, while the curious aspect is that the circuit from Arequipa to Trujillo almost never exhibits this form of sporadic E propagation.

Often during the evening and nighttime hours on the Antofagasta to Guayaquil path (but not on the Antofagasta to Trujillo path) there is observed a strong signal increase which appears to correlate well with the occurrence of spread F on the vertical incidence sounder at Huancayo. While it had been expected that F-region scatter might take place over this long-path circuit much of the time, this is evidence that it can occur at night.

The cooperation and participation of the IGY committees of Argentina, Brazil, Chile, Ecuador, and Peru was an indispensable part of this experiment, and the assistance by the governments of these countries was greatly appreciated.

Radio Noise Network

Radio noise is a basic limitation to long distance radio reception, and in particular, the background of radio noise originating from natural causes in the atmosphere is often a severe restriction to good radio communication. Therefore, a detailed knowledge concerning the distribution of noise levels throughout the world and an understanding of the noise characteristics is fundamental to the advancement of communication techniques. For this reason, during the IGY a worldwide network of stations recording radio noise levels was put into operation by NBS under the supervision

of W. Q. Crichlow, R. T. Disney, and C. A. Samson.

In any radio noise measurements the following three parameters are useful: (1) the mean power, (2) the mean envelope voltage, and (3) the mean logarithm of the envelope voltage. In addition to measurements made with the NBS Radio Noise Recorder, ARN-2, in the worldwide network instantaneous amplitude probability distributions were obtained at Boulder, Colorado. These distributions provide information concerning the detailed character of the noise from which its interference properties can be determined.

Preliminary results would indicate that the worldwide predictions published elsewhere are too simplified. The behavior of radio noise, as a function of the frequency, time of day and season, differs widely from location to location. Specific local conditions need to be well understood in order to make accurate predictions.

Thus, afternoon noise levels in areas of high local thunderstorm activity may be 20 to 30 db higher than indicated by the predictions. Boulder, Colorado is a good example of this, since it is located near one of the most active thunderstorm regions in the United States—the front range of the Rocky Mountains. On certain days the variation may be as much as 70 db, on some frequencies. In contrast, at Kekaha, Hawaii, the minimum noise levels for the low frequencies tend to occur near sunset instead of a few hours after sunrise as at most stations. As a result, the 160-kc afternoon noise levels appear to be 20 to 30 db lower than predicted at this location. The nighttime noise levels at Boulder are often lower than predicted, while at Kekaha they agree rather well with the predictions.

Radio Satellite Observations

With the successful launching, during IGY, of earth satellites, permanent interferometer equipment was installed at Table Mesa near Boulder to record transmissions

passing through the ionosphere from these satellites. Pairs of half-wave dipoles, with horizontal east-west polarization at one third wave length above the ground, were set up at the corners of equilateral triangles of 3,000-foot and 150-foot spacing. Observations were made at both 20 and 40 mc. In addition, circularly polarized antennas were installed. The output is recorded on magnetic tape or on two 6-channel Sandborn recorders. The equipment is fully automatic and can be set for automatic operation during the passage of a satellite beacon transmitter at these frequencies. Two Yagi antennas on a frequency of 108 mc and a vertically polarized antenna for 20 mc have also been installed. With this arrangement of antennas, measurements of angle of arrival, Faraday rotation, polarization, scintillation, diversity effects, and Doppler frequency changes have been made. The satellite ionospheric measurements program at the National Bureau of Standards is under the direction of C. G. Little.

Inspection of the Faraday fading records of the 20 mc signals made during the first 4 months of satellite 1958 Delta (Sputnik III) show the following systematic variations in the fading rate: (a) The fading rate is slowest when the satellite is in the north and greatest when it is in the south; (b) the greater height of the satellite during the north-to-south passes, and hence the longer ionospheric paths of the radio signals, account for the greater fading rates during these passes than during the south-to-north passes; (c) nighttime passes are characterized by a fading rate that is much slower than for daylight passes at the same height. When the fading rate was compared with the square of the F-layer critical frequency, taken from the Boulder ionograms, it shows that the daily variations in fading rate are largely due to the daily variations in the ionization content of the ionosphere. Many of the Faraday-rotation rates, rather than varying smoothly throughout a single passage of the satellite, vary irregularly and

indicate the existence of ionospheric irregularities. In some instances these irregularities are of the order of 100 km in lateral extent. Calculations using the 20 mc signal from 1958 Delta show that the observed irregularities in the Faraday rotation rate can be accounted for if the integrated electron content, along the line of sight, per square centimeter column, varies irregularly with variations of the order of 10^9 during 1-km change (horizontal) in satellite position. From a determination of the number of complete rotations of the plane of polarization of the radio signal, the total electron content, up to the height of the satellite, can be calculated. For a pass of this satellite, at a height of about 236 km, low in the F region, the integrated electron content in a vertical column was estimated as 2.7×10^{12} electrons/cm² column.

In conjunction with the satellite observations a computer program is being set up for tracing the paths of the rays between the satellite and the receiver. The ordinary and extraordinary rays are traced separately through the ionosphere and the difference in their phase paths gives the instantaneous orientation of their polarization vector. Actual ionospheric profiles from ionograms are used up to the F-region peak, but various assumed profiles are tried for the upper ionosphere. The ray-tracing program is coupled to a program which gives successive positions of the satellite along an elliptical orbit. The combination of these two programs gives a complete picture of the Doppler frequency, the Faraday rotation, and the angle of arrival of the satellite signal. A comparison between the direction of arrival and line of sight to the satellite gives a measure of the angular errors introduced by the ionosphere.

Airglow Observations

The atoms and molecules of the earth's upper atmosphere continuously radiate a flux of light and radiation. During the daylight hours this flux is swamped by a much

stronger energy flux from the sun, but at night the airglow emitted from the high atmosphere can be easily detected by sensitive photometers and on occasion it can be seen by the human eye. Closely related to the airglow emission, and perhaps a part of the same phenomenon, is the well known and often observed aurora associated with high-latitude belts on the earth. Because of its wide distribution and constant occurrence, it was logical that a worldwide study of the airglow be undertaken as a part of the IGY synoptic program. F. E. Roach has directed the NBS airglow program, involving observation stations at Fritz Peak, Colorado, and Rapid City, South Dakota. In addition, the group constructed photometers for College, Alaska; Huancayo, Peru; and Sidney, Australia. The photometer itself is of a hybrid design combining the Lyot birefringent filter principle, as adapted by J. Blamont and A. Kastler and used by R. B. Dunn and E. Manring, with the telescope system designed by F. E. Ross. The telescope has a 6-inch objective, a focal length of 13 inches, and a 4-degree field of view. A series of color filters permit the selection of one of the following emissions characteristic of the night airglow: OI ($^1S_0 - ^1D_2$) at 5577 Å, OI ($^1D_2 - ^3P_1$) at 6300 Å, and NaI ($^2P_{3/2} - ^2S_{1/2}$, $^2P_{1/2} - ^2S_{1/2}$) at 5890 and 5896 Å. In addition there are many strong bands of emission in the infrared from the OH molecule. The photometer is programmed to sweep the sky in successive almucantars (circles of the celestial sphere parallel to the horizon) at angles of 80°, 75°, 70°, 60°, 40°, and the zenith. It sweeps the entire sky in 4 minutes at each wavelength and returns once each 15-minute interval to repeat the wave-length sequence. The data are recorded on a strip chart recorder and transferred to punch cards for IBM 650 processing.

In addition to the photometer described above, a simple photometer of the Roach-Elvey type was installed at Thule, Greenland, in October 1958 for special observations at the magnetic pole. There was also

installed an all-sky camera and a patrol spectrograph at Fritz Peak and at Rapid City.

An analysis of the nightglow observations at 5577-Å shows the emission to come from a height of approximately 100 km. Direct measurements of the altitude of the night airglow obtained from rockets show the maximum of the 5577-Å layer to be near 98 km. Systematic isophote airglow maps of the night sky throughout many nights have been prepared and a careful analysis of these maps made. This analysis shows the sky to contain discrete airglow cells of 5577-Å emission, having a characteristic diameter of 2500 km and moving with translational speeds of about 100 m/sec. These airglow cells appear to exhibit a rotational period of about 5 hours.

In order to investigate the possibility that the 5577-Å night airglow, present over the earth as a whole, may be closely related to the aurora, which is prevalent in high-latitude regions, the CRPL investigators have made a statistical analysis concerning the frequency of occurrence of these phenomena. Although this type of statistical treatment is open to some question, it may give a clue as to whether or not these two phenomena, the airglow and the aurora, have a common origin.

World Data Center A—Subcenter for Airglow and Ionosphere

Located in the Boulder Laboratories of the National Bureau of Standards is IGY World Data Center A, Subcenter for Airglow and Ionosphere Data. The Data Center is under the supervision of W. B. Chadwick and S. M. Ostrow. To this subcenter, all airglow and ionospheric stations in the western hemisphere and Australia and New Zealand send their data for copying and filing. In this manner, a central file of the results of the IGY observations will be made available for research and study for many years to come. It was the responsibility of this subcenter during the IGY to

send or arrange for sending copies of the data to World Data Centers B, C1, and C2 located in the USSR, England, and Japan respectively. These centers in return send data from the laboratories in their area of responsibility to Boulder. This subcenter,

in addition to maintaining files of the data, prepares catalogues and indexes of the data, makes copies of the data available to scientists, organizations, and others, and maintains office space where visiting research workers can come for study.

IGY Satellite 1959 Iota

Carrying the largest payload and the most varied set of experiments in the US-IGY satellite effort, 1959 Iota (Explorer VII) was launched on October 13, 1959, at 11:30:05 am EDT. The satellite was injected into orbit at 11:39:33 am EDT.

The approximate orbit of 1959 Iota as of October 14 was: Perigee, 344.5 statute miles; apogee, 677.9 statute miles; period, 101.35 minutes; inclination of orbit to equator, 50.3°; velocity at perigee, 17,275 statute miles per hour; and velocity at apogee, 16,034 statute miles per hour.

1959 Iota was placed in orbit by the Army Ballistic Missile Agency, under sponsorship of the National Aeronautics and Space Administration, as a contribution to the IGY and its 1959 extension, International Geophysical Cooperation-1959. Although it is the last of the satellites scheduled as part of the US-IGY and IGC-59 programs, scientific results from future United States satellites will continue to be contributed to the international space science program being coordinated by the ICSU Committee on Space Research (COSPAR).

Scientific experiments carried by 1959 Iota include measurements of the earth's radiation balance, heavy primary cosmic rays, solar ultraviolet radiation and X-

radiation, micrometeorites, cosmic rays and less energetic particles, lifetime of an unprotected solar cell, and surface and interior temperatures. In addition, the 20 mc primary telemetry frequency and its 40 mc and 60 mc harmonics permit ground-based studies of the ionosphere.

Launching

1959 Iota was placed in orbit by a Juno II launching vehicle modified by the addition of a support cylinder to the fourth stage to support the weight of the payload.

This was the fifth firing of the Juno II vehicle. Previously it had been used to launch successfully the space probes Pioneer III and Pioneer IV, and in the unsuccessful attempts to launch the forerunner of 1959 Iota on July 16, 1959, and a 12-foot inflatable sphere on August 14, 1959.

The Juno II rocket system has four stages, is 76 ft long overall, and weighs about 60 tons including fuel. The first stage is a modified Jupiter rocket developed by ABMA. The Jet Propulsion Laboratory of the California Institute of Technology developed the upper stage assembly consisting of 15 scaled-down solid-propellant Sergeant rockets. The second stage contains 11 of these rockets, each 42.5 inches long

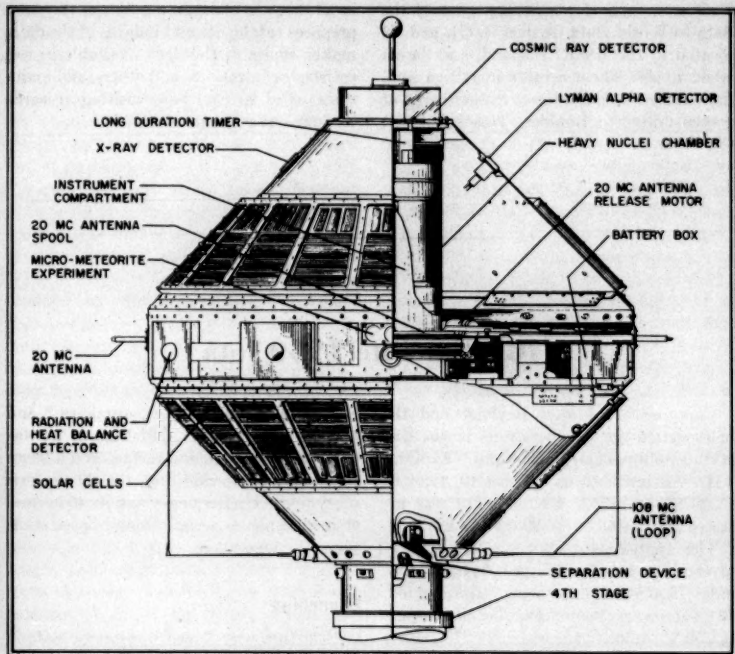


Fig. 9. 1959 Iota, Carrying Largest Payload of US-IGY Satellite Effort, In Cutaway View. Adapted from a US Army photograph released by NASA.

and 6 inches in diameter, arranged in cylindrical fashion. A cluster of 3 similar rockets fitted inside the cylinder is the third stage. The fourth stage, to which the payload is attached, is a single rocket fitted inside the third stage cluster.

During launch and first-stage flight, the whole upper stage cluster is protected by an aerodynamic shroud which is released by explosive bolts and pushed aside by a lateral rocket prior to upper stage ignition.

The Delta Minimum Inertial Guidance Scheme, located in the forward part of the first stage, furnishes guidance for the vehicle. Once trajectory information has been fed into this guidance system, prior to ig-

nition, it operates automatically. The only ground-to-vehicle control is the safety destruct system.

Satellite Characteristics

1959 Iota weighs 91.5 lbs. Shaped like a double cone joined by a center ring, the satellite is 30 inches long and 30 inches wide at maximum diameter. Its shell is composed of plastic-impregnated Fiberglas.

Experiments and Instrumentation

The successful launching of 1959 Iota brought to fruition planning by the USNC-

IGY Technical Panel for the Earth Satellite Program under the chairmanship of Richard W. Porter. Herman E. LaGow, Head of NASA's Planetary Atmospheres Branch, was the satellite project officer. The satellite was designed, fabricated and tested by ABMA under the direction of Ernst Stuhlinger and Joseph Boehm.

Radiation Balance Measurements: This experiment is being conducted by Verner E. Suomi of the University of Wisconsin. It is a study of the thermal radiation budget which is thought to influence greatly the earth's weather.

Near the equator, the earth receives more energy from the sun than it radiates into space; conversely, it radiates more energy into space in polar regions than is received there from the sun. The transfer of energy from lower latitudes to higher latitudes is being studied in this Wisconsin experiment by measuring direct radiation from the sun; the fraction of this radiation diffusely reflected by the earth, clouds and atmosphere; and the fraction of radiation which is converted into heat by the earth and ultimately re-radiated back into space in the far infra-red portion of the spectrum.

Six sensing elements are used: two hemispheres and one sphere painted black to measure total energy at all wavelengths; one hemisphere painted white to measure radiation of longer wavelengths while reflecting shorter wavelengths; and two sensing elements (Tabor sensors) with a special coating to measure short wavelengths only. The Tabor sensors are about one inch in diameter, the black and the white sensors about one and one-quarter inch in diameter. The measurements are made by means of thermistors, or electronic thermometers, contained in each sensor.

Solar Ultraviolet and X-radiation Measurements: This experiment is being conducted by Herbert Friedman, Superintendent of the Atmosphere and Astrophysics Division, US Naval Research Laboratory, with the assistance of Talbot A. Chubb and

Robert W. Kreplin of NRL. The purpose of the experiment is to measure solar ultraviolet and X-ray intensities and their variations, particularly during solar flares.

Solar ultraviolet, or Lyman-alpha, radiation is being measured by means of two photosensitive ionization chambers cylindrical in shape, three-quarters of an inch in diameter, and one and one-quarter inches long. The chambers are fitted with windows of lithium fluoride transparent to wavelengths of 1040 to 1340 Angstroms; the only radiation of notable intensity in this band is the Lyman-alpha line of atomic hydrogen at 1216 Angstroms.

The two X-ray detectors are similar in size and shape to the Lyman-alpha ionization chambers. The X-ray ionization chambers are filled with argon gas, have beryllium windows, and are sensitive to wavelengths of 3 to 15 Angstroms.

A photo cell is included in this experiment to enable the experimenters to determine the aspect of the satellite with respect to the sun.

Heavy Primary Cosmic Ray Measurements: This experiment was designed by the late Gerhart K. Groetzinger of the Martin Company's Research Institute for Advanced Studies (RIAS). It is being carried on by Martin A. Pomerantz, director-elect of the Bartol Research Foundation, and Philip Schwed, also of RIAS. The experiment is designed to determine the flux of heavy primary cosmic rays with atomic numbers greater than 6 (carbon), 9 (fluorine), and 16 (sulfur). It uses an ionization chamber closed at both ends and filled with argon gas. The voltage maintained between an insulated metallic wire along the axis of the cylinder and the wall of the chamber is such that the wire collects all the electrons produced by the passage of charged particles through the argon gas. The total charge reaching the central wire is proportional to the total ionization generated by the particle and hence measures the charge of the particle.

Ground-based Ionospheric Observations: The 20 mc primary telemetry frequency (and its two harmonics) selected for the transmitter in this final US-IGY satellite provides an opportunity for researchers to learn more about the earth's ionosphere. IGY-sponsored ionospheric investigations are being conducted by G. W. Swenson, Jr., University of Illinois; C. G. Little, National Bureau of Standards, Boulder, Colorado; G. C. Reid, University of Alaska; O. G. Villard, Jr., Stanford University; W. J. Ross, Penn State University (with slave stations for simultaneous observations at Charlottesville, Virginia, and Columbus, Ohio); W. P. Dyke, Linfield Research Institute, McMinnville, Oregon. In addition, scientists throughout the world received advance word of the precise frequencies in order to make appropriate preparations for additional ionosphere studies. The world scientific community was also informed of the successful launch of 1959 Iota through AGIWARN and COSPAR.

Micrometeorite Measurements: This experiment is being conducted by Herman E. LaGow of NASA; the work was initiated when he was at NRL. A cadmium sulphide photo conductor is covered with an optically opaque film. An impact of a micrometeorite larger than about 10 microns in diameter will damage the film and permit sunlight to enter the cell. This causes a drop in the output resistance of the detector. Information about orientation of the cells is provided by data from Friedman's solar aspect cell.

Cosmic Ray Measurements: This experiment is being conducted by James A. Van Allen of the State University of Iowa, assisted by George H. Ludwig, who planned and designed the instruments, and William Whelpley, who was in charge of constructing and testing them. Two Geiger-Mueller tubes are measuring cosmic radiation and less energetic particles in the lower fringes of the inner Van Allen radiation belt and the space just below. One tube, an Anton 302 similar to that flown in 1958 Epsilon

(Explorer IV), is unshielded; it is $\frac{3}{4}$ inch in diameter and 3 inches long. The other tube, an Anton 112 about $\frac{7}{8}$ inch in diameter and $2\frac{1}{2}$ inches long, has a lead shield about 1 mm thick.

Exposed Solar Cell Measurement: This experiment is being conducted by ABMA and the US Army Signal Research and Development Laboratories to determine the performance of an unprotected solar cell in a space environment. The effect of erosion upon a silicon cell mounted on the equator of the satellite is indicated by variation in the voltage developed by the cell when illuminated by incident light.

Temperature Measurements: Temperature measurements are being made in an isolated area of the satellite surface, in a solar cell cluster, in a battery pack, and in one of the Geiger-Mueller tubes.

Radio Equipment

1959 Iota carries two radio transmitters. One transmitter, powered by solar cells, transmits all data except micrometeorite measurements continuously on 19.9915 megacycles. It transmits over a turnstile type antenna consisting of four flexible quarter wavelength elements. This transmitter also radiates two harmonics at 39.9830 and 59.9745 megacycles. The all-transistor transmitter feeds 600 milliwatts to the antenna at fundamental frequency, and 15 milliwatts and 3 milliwatts respectively at the second and third harmonics.

The second transmitter, powered by chemical batteries, transmits micrometeorite data and a tracking signal continuously at 108.00 megacycles. This transmitter feeds 15 milliwatts to a modified loop antenna.

The solar cells are located in six clusters of 481 cells each, so arranged that attitude control for the satellite is not required. An automatic timing device will cut off the solar-powered transmitter one year after launching. The nickel-cadmium batteries

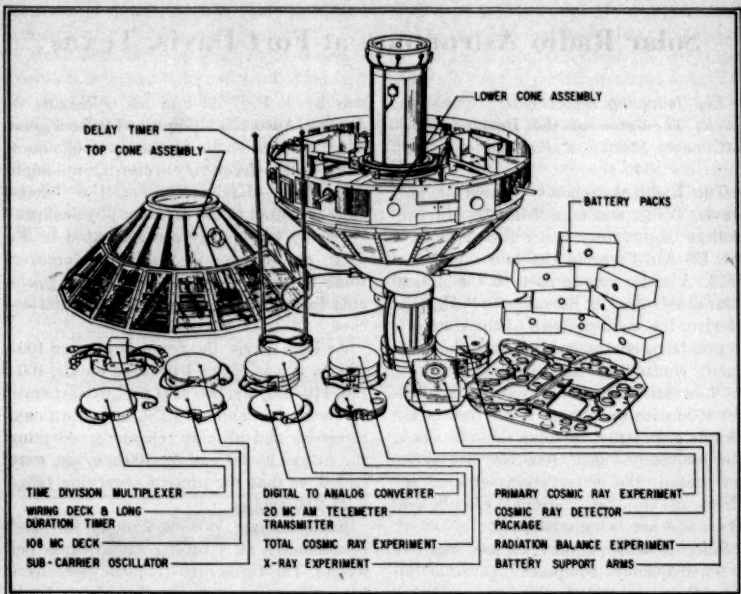


Fig. 10. Partially Disassembled View of 1959 Iota Showing Some of Experiments Carried. Adapted from a U. S. Army photograph released by NASA.

supplying power to the 108 megacycle transmitter are expected to have a lifetime of about two months.

Tracking

More than 20 stations around the world are tracking 1959 Iota and recording scientific data. NASA Minitrack stations at Blossom Point, Maryland; San Diego, California; Santiago, Chile; Esselen Park, South Africa; and Woomera, Australia, are equipped both for tracking and data acquisition. The Minitrack stations at Quito, Ecuador; Lima, Peru; and Antofagasta, Chile, are tracking the satellite on 108 mega-

cycles. The University of Heidelberg in the German Federal Republic is recording 20-megacycle information.

Initial tracking of 1959 Iota was accomplished by US Army Microlock stations at Aberdeen Proving Ground, Maryland; Cape Canaveral, Florida; Huntsville, Alabama; Cape Hatteras, North Carolina; Fort Monmouth, New Jersey; Van Buren, Maine; and on Bermuda.

Baker-Nunn cameras at twelve stations around the world and the worldwide network of Moonwatch teams, both supervised for NASA by the Smithsonian Astrophysical Observatory, also are tracking the satellite.

Solar Radio Astronomy at Fort Davis, Texas

The following report was prepared by A. R. Thompson of the Harvard Radio Astronomy Station at Fort Davis.

The Radio Astronomy Station at Fort Davis, Texas, was established by Harvard College Observatory under the auspices of the US Air Force in the late summer of 1956. A radio counterpart to the optical solar observatory at Sacramento Peak, New Mexico, the main purpose of the station is to provide a continuous record of the radio bursts emitted by the active sun.

Observations were begun during September 1956 with equipment which records the complete spectrum of solar radio bursts in the frequency range 100–580 megacycles per second. The observations covered the whole of the International Geophysical Year, and are being continued.

Since it was planned to use sensitive sweep-frequency equipment covering almost three octaves of the radio spectrum, it was mandatory to select an observing site at which the level of man-made interference is very low. For this reason, the station was located in a remote valley in the Davis Mountains of West Texas. The surrounding mountains rise about 1500 feet above the level of the site, and provide excellent shielding from unwanted radio signals. The station is virtually free from interference at frequencies above 40 mc/sec, only one weak television signal and a few intermittent radio-telephone signals ordinarily being detectable. The site was chosen by Alan Maxwell, who has directed the program at Fort Davis since its inception.

Equipment and Experimental Techniques

The first use of sweep-frequency equipment for the study of solar radio bursts

was by J. P. Wild and his colleagues in Sydney, Australia, and proved to be a great advance over single-frequency techniques. With sweep-frequency records, a simple system of classification of the bursts, closely related to the different physical processes by which they are generated in the solar atmosphere, is possible. Moreover, solar bursts are immediately distinguishable from intermittent man-made interference.

At Fort Davis, the frequency range 100–580 mc/sec is covered in three bands, 100–180, 170–330, and 300–580, by three separate receivers. In January 1959, two additional receivers and display channels, covering the ranges 25–50 and 50–100 mc/sec, were added, so that the present observing range is 25–580 mc/sec.

Each receiver sweeps through its band continuously at a rate of three times per second. The three high-frequency receivers are connected to separate broad-band primary feeds at the focus of a 28-foot paraboloid antenna. This antenna is equatorially mounted and tracks the sun from rising to setting throughout the day. The two low-frequency receivers are connected to fixed arrays that do not track the sun, but have broad beams directed along the meridian at the celestial equator, so that the sun can be monitored for the greater part of the day. The outputs of the receivers are displayed on separate cathode-ray tubes, which are intensity-modulated and photographed by a continuously moving film; the film records the intensity of the bursts as a function of frequency and time.

The equipment is switched on automatically at sunrise each day and the receivers are calibrated in frequency and intensity after sunset each evening. In the daily observing routine, great emphasis is placed on continuity of observations, and an average of less than 5% of possible observing

time has been lost through equipment failure, etc.

More than 90% of solar radio emission recorded at Fort Davis can be divided into the four spectral classes shown in Fig. 11.

Noise storms (Type I) consist of a series of irregular radio-frequency bursts, often superimposed on an enhanced background of steady radiation. They may last for many hours, or even days, and are associated with the presence of large sunspots.

Slow-drift bursts (Type II) are characterized by a band of emission that drifts steadily toward the lower end of the frequency spectrum over a period of about five minutes. They are often very intense and show a high degree of association with the occurrence of solar flares. **Fast-drift bursts** (Type III) last for a few seconds only, and drift rapidly toward lower frequencies. They are very common, often occurring in groups. More than 10,000 fast-drift bursts per year have been recorded at the Fort Davis station. The great **continuum outbursts** (Type IV) are intense bursts of radiation lasting for as much as 12 hours and often covering several octaves of the radio-frequency spectrum.

The film records are analyzed at Fort Davis, and all bursts are classified according to spectral type and listed with time of occurrence and intensity. Quarterly summaries of the radio bursts were distributed by the station during the IGY, and publication of this information is continuing through the International Astronomical Union (Zurich) *Quarterly Bulletin of Solar Activity*, and the Central Radio Propagation Laboratory (Boulder, Colorado) *Monthly Bulletin of Solar Geophysical Data*.

A detailed analysis of observations taken during the first two complete years of operation, October 1956 through September 1958, has now been made. This analysis includes correlation of the four types of bursts with solar flares and prominences, geomagnetic activity, and variations in cosmic-ray intensity, and an investigation of the duration and intensity of solar bursts as related to their interference with communications signals. (Several reports on these analyses by personnel of the Fort Davis Station have been published or are now in the process of publication.)

The slow-drift bursts and the great continuum outbursts present the most interesting associations with other geophysical phenomena; these are briefly reviewed below.

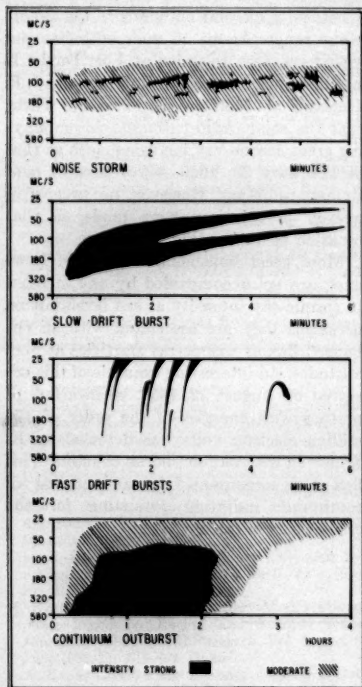


Fig. 11. Idealized Examples of the Records of the Four Spectral Types of Solar Radio Bursts. A special form of fast-drift burst, known as an inverted "U" burst, is also shown.

Slow-Drift Bursts

About 30 slow-drift bursts per year are observed at Fort Davis during solar maximum. The origin of a slow-drift burst is currently attributed to oscillations in the solar atmosphere at the local plasma frequency, which varies with the electron density. The drift of the burst toward lower frequencies therefore indicates that the point of origin moves outward through the solar atmosphere, traversing regions of progressively lower electron density.

From the rate of change of the frequency of emission, it is estimated that the rate of motion of the source is about 1000 km/sec. This is similar to the velocity usually attributed to solar auroral particles, and corresponds to a time of travel between the sun and the earth of approximately 40 hours. The suggestion immediately follows that a slow-drift burst may be caused by the emission during a flare of a stream of auroral particles, exciting plasma-frequency oscillations as it traverses the sun's corona.

The Fort Davis observations show that a significant association exists between the occurrence of slow-drift bursts and of subsequent geomagnetic storms. During September 1957, seven slow-drift bursts were recorded at Fort Davis; this was the greatest number for any month during the IGY. September 1957 was also the month of greatest geomagnetic activity ever recorded. Six major magnetic storms occurred, and five of these were preceded by slow-drift bursts recorded at Fort Davis. Over the two-year period October 1956–Septem-

ber 1958, at least 60% of magnetic storms were preceded by slow-drift bursts. Unfortunately, the available sweep-frequency data, recorded both at Fort Davis and Sydney, Australia, covers on the average just less than 2/3 of each day, and it is therefore impossible to know whether all magnetic storms were preceded by slow-drift bursts.

Continuum Radiation

The intense, long-duration examples of continuum radiation are perhaps the most spectacular of solar outbursts in the meter-wave range. About 15 such outbursts per year have been recorded at Fort Davis. It has been suggested by A. Boischot and J. F. Denisse, of Meudon Observatory, Paris, that the solar radio outbursts accompanying great cosmic-ray increases, such as that of February 23, 1956, were cases of continuum radiation. However, no sweep-frequency observations were made on that occasion to verify this suggestion.

Most great continuum outbursts, however, are not accompanied by any increase in cosmic-ray intensity at sea level, but on occasions they are associated with an enhanced flux of cosmic-ray particles at high altitudes. An interesting example of this occurred on August 22, 1958, when a flux of protons with energies of the order of 170 million electron volts was detected by K. Anderson with balloon-borne counters. This flux was accompanied by an outburst of continuum radiation persisting for the greater part of the day.

IGY Bibliographic Notes

This is the sixteenth of a series of bibliographic notes on IGY and IGC-1959 programs and findings. The references are selected largely from a bibliography under preparation in the Science and Technology Division of the Library of Congress. (An interim IGY bibliography, covering the period January 1961-August 1958, prepared by the Library and published by the Academy with support of the National Science Foundation, is available from the Academy, 2101 Constitution Avenue, N. W., Washington 25, D. C., for \$1.00. The 64-page volume contains 704 references.)

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IGY BULLETIN

A monthly survey of programs and findings of the International Geophysical Year and the International Geophysical Cooperation-1959 as related primarily to United States programs.

Radiation Measurements in the Vicinity of the Earth and Moon

The following material is based on two reports by James A. Van Allen (one in collaboration with Louis A. Frank) of the Department of Physics and Astronomy, State University of Iowa. The reports have been published elsewhere in full: the first, "Radiation Measurements to 658,300 Kilometers with Pioneer IV," by Van Allen and Frank, appeared in *Nature*, July 25, 1959; the second, "The Geomagnetically Trapped Corpuscular Radiation," appeared in the *Journal of Geophysical Research*, November 1959.

An earlier report on radiation and magnetic-field measurements to distances of many earth radii, by US-IGY satellites and space probes, was presented in *Bulletin No. 21*. Since then, additional data gathered by US-IGY space probe Pioneer IV have been reduced and analyzed. Some data from the first USSR space probe have also become available. This report, based primarily on the analyses of Pioneer IV data, extends and amplifies some of the earlier results.

Pioneer IV

Launching and Flight: Pioneer IV was launched from Cape Canaveral, Florida, at 0511 UT on March 3, 1959. The launching was accomplished by the Army Ballistic Missile Agency and the Jet Propulsion

Laboratory (JPL) of the California Institute of Technology under the management direction of the National Aeronautics and Space Administration (NASA).

The 13.4-pound, conical, gold-plated probe reached approximately its nearest approach to the moon, 60,149 kilometers (or about 37,370 miles), at 2300 UT on March 4. The probe then continued onward into a heliocentric orbit, sending back usable radiation data until 1500 UT, March 6, when its mercury batteries went dead. At this time, about 82 hours after launch, the probe had reached a point about 658,300 kilometers (or about 409,100 miles) radially from the center of the earth, a record distance for maintaining radio contact.

Objectives: The radiation experiment in Pioneer IV had the following objectives: (i) re-survey of the intensity structure of the zones of trapped radiation surrounding the earth, with special emphasis on time changes since December 6-7, 1958 (flight of Pioneer III, which reached an altitude of about 63,500 statute miles); (ii) crude determination of the absorptivity (ratio of absorbed to incident radiation) of the trapped radiation in terms of spatial position, in order to increase knowledge of its composition and spectral character; (iii) re-determination of the effective extent of the geomagnetic field; (iv) search for magnetically trapped radiation in the vicinity of the

moon; (v) re-determination of cosmic-ray intensity in interplanetary space; and (vi) search in interplanetary space for "blobs" of plasma containing particles of sufficient energy to be detected by the equipment carried.

Over-all management of the Pioneer IV program rested with NASA. The radiation experiment was directed by James A. Van Allen of the State University of Iowa (SUI), with financial support from JPL.

Instrumentation: The radiation instrumentation was identical to that flown in Pioneer III (see *Bulletins 20 and 21*) except that one of the two radiation counters used, an Anton 213 Geiger-Mueller tube, was shielded by a closed-end cylinder of lead 4.0 gm/cm^2 thick and an inner cylinder of stainless steel 0.6 gm/cm^2 thick, thus allowing discrimination of the higher-energy radiation. (See Figure 1.) The other counter, an Anton 302 Geiger-Mueller tube, was, like those used in Pioneer III, relatively unshielded. The radiation detectors and the

payload assembly were developed, calibrated, and tested cooperatively by JPL and SUI.

Radiation data were telemetered to JPL receivers at Cape Canaveral, Florida, Mayaguez, Puerto Rico, and Goldstone Lake, California. The University of Manchester's 250-foot paraboloid radio telescope at Jodrell Bank, England, under the direction of A. C. B. Lovell, also was used to track the probe.

The Geomagnetically-Trapped Radiation

After the initial discovery by US-IGY satellite Explorer I of radiation of rapidly increasing intensity above a height of about 1000 kilometers, it was concluded that this radiation must consist of charged particles trapped in the earth's magnetic field. (See *Bulletin No. 27* for a discussion of the mechanics of trapping of radiation in the magnetic field.) Subsequent measurements by additional satellites and space probes provided a wealth of evidence to support this conclusion, which may now be regarded as established beyond doubt. The following discussion in this section concerns the intensity structure, character, variations, origins, and geophysical effects of this geomagnetically trapped radiation.

Intensity: In Figure 2, the counting rates of the nearly identical Anton 302 tubes of both Pioneer III and Pioneer IV are plotted against radial distance from the center of the earth. Also shown is the equivalent counting rate of the heavily shielded 213 tube for the first part of the Pioneer IV flight. Figure 3 shows the paths of both probes through the Van Allen radiation zones.

The most striking features evident in Figure 2 are (i) the immensely greater quantity of radiation trapped in the outer radiation zone on March 3, 1959, (over 300,000 counts/sec), than on December 6, 1958, (about 25,000 counts/sec); (ii) the considerable outward extension of the outer

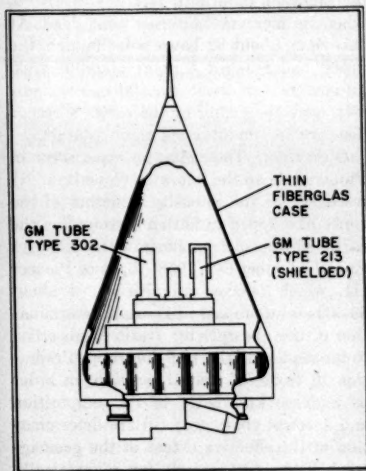


FIG. 1. Payload of Pioneer IV.

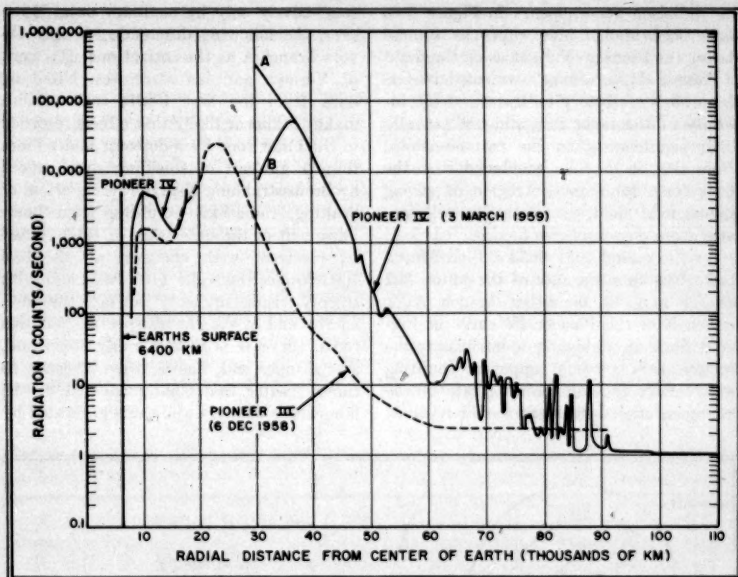


FIG. 2. Comparative Plots of Intensity Data from Pioneer III and Pioneer IV. Same scale is used for both plots but differences in latitude and longitude are ignored.

zone (about 15,000 kilometers); and (iii) the detailed intensity structure present in the March 3 record, especially in the 60,000-90,000 kilometer region.

S. N. Vernov and his associates report that observations with the first Soviet space probe show that the radiation pattern on January 2, 1959, was similar to that on December 6-7, 1958.

The High Altitude Observatory, at Boulder, Colorado, reports that a substantial geomagnetic storm began at 0215 UT, February 25, 1959, and that intense auroras occurred on February 25, 26, 27, and 28 and on March 1. A special study by D. E. Trotter of HAO indicates that at least three sequences of geophysical events starting on February 25, March 26, and April 23, 1959, may have been caused by a solar M-region. (An M-region is an active region of the sun

emitting a continuous, limited beam of solar corpuscles, causing geomagnetic storms to recur at about 27-day intervals in accordance with the sun's rotation.)

The periods preceding the flights of Pioneer III and the first Soviet space probe, on the other hand, were especially quiet geophysically. Hence, the SUI investigators suggest that the great intensity differences shown in Figure 1 between the flights of December 6, 1958, and March 3, 1959, constitute a direct observation of changes in the outer zone of trapped radiation following strong corpuscular emission from the sun. Thus, if this view is accepted, it appears that the Pioneer IV observations are the most persuasive direct evidence thus far available in support of the solar origin of at least the outer radiation zone.

Although the peak of the inner Van Al-

len radiation zone appears in Figure 2 to have been about three times as intense during the Pioneer IV flight as on the flight of Pioneer III, certain adjustments based on the probe's trajectory indicate that the intensity of the inner zone did not actually differ significantly on the two occasions. From this, it may be concluded that the inner zone, lying in the region of strong geomagnetic field, is relatively well isolated from direct solar influence.

For the period 0631-0653 UT on March 3, the true counting rate of the Anton 302 counter may lie on either branch A or branch B of the Pioneer IV curve in Figure 2. Such an ambiguity is intrinsic to the characteristic curve of apparent counting rate relative to true counting rate of the instrumentation system and can be resolved

conclusively only by auxiliary data. However, the following discussion strongly favors branch A as the correct one: the work of Vernov and his associates, based on data from the first USSR space probe, makes it appear likely that effects recorded in the outer zone by a detector under more than 1 gm/cm^2 of shielding were caused by bremsstrahlung X-rays (deceleration, or braking, radiation) resulting from bombardment of the outer skin of the payload by electrons with energies of less than 100,000 electron volts (100 kev) and with steeply rising intensity toward the low-energy end of the energy spectrum; if this is so, curve B is unreasonably steep and, at its inner end, has a value at least 10 times greater than that measured in the laboratory with X-ray beams generated by

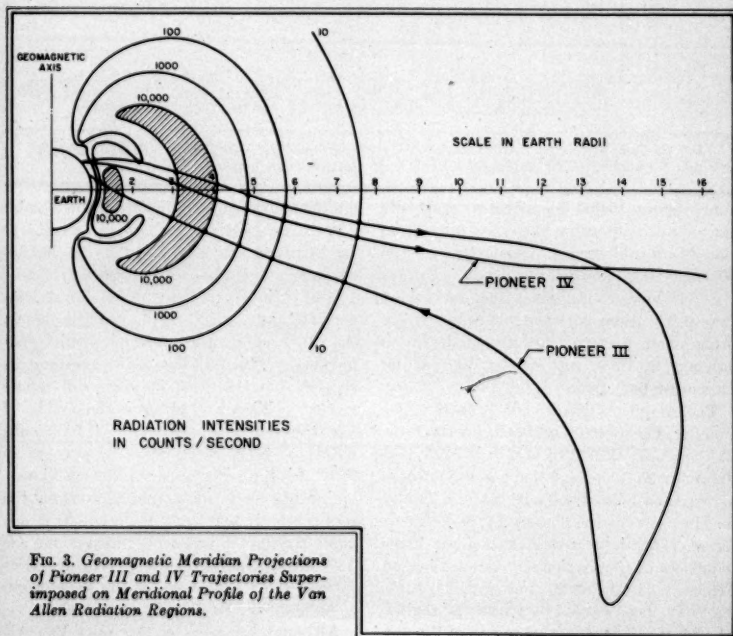


FIG. 3. Geomagnetic Meridian Projections of Pioneer III and IV Trajectories Superimposed on Meridional Profile of the Van Allen Radiation Regions.

electrons of similar energies; curve A, on the other hand, is altogether consistent with this radiation situation.

Character: Because of their universality in nature, it was originally supposed that electrons were present in the trapped radiation. Also, among the many nuclear possibilities, it was thought that protons (H^+) were most likely dominant because of the preponderance of hydrogen as an atomic constituent of matter. If the hypothesis that the trapped radiation consists of electrons and protons is accepted, the problem of further determining the nature of the radiation then becomes one of measuring the energy spectrum of each of the two components as functions of position in space, direction, and time. Despite the fact that the measuring equipment used thus far in rockets, satellites, and space probes is, by laboratory standards, relatively rudimentary, available observations provide a good general picture of the nature of the trapped radiation.

It has been demonstrated conclusively that the composition and energy spectra of the components of the trapped radiation in the inner Van Allen zone are quite different from those of the radiation trapped in the outer zone; the difference from one zone to the other is much greater than that between various parts of a particular zone.

The intensity of the radiation in the inner zone decreases by a factor of 10 between ranges of 1 mg/cm^2 and about 140 mg/cm^2 . It falls off more gradually at ranges above 140 mg/cm^2 . (Range refers to the penetrating power of a particle—i.e., the particle would penetrate any material to a thickness at which a cm^2 column would have the weight indicated.) Of the radiation that penetrates 140 mg/cm^2 , a fraction of 1% also penetrates several gm/cm^2 . This more penetrating component is tentatively identified as protons with energies of the order of 100 million electron volts (mev). The less penetrating component has a low specific ionization and, there-

fore, probably consists of electrons with energies up to about 1 mev and having an energy spectrum rising steeply toward lower energies (though not as steeply as that of auroral soft radiation—the relatively low-energy corpuscular radiation originating in solar flares and thought to cause the aurora).

Total energy fluxes as high as $100 \text{ ergs/cm}^2/\text{sec}/\text{ster}$ have been recorded beneath 1 mg/cm^2 of shielding at an altitude of about 2000 kilometers near the geomagnetic equator. (One erg equals approximately $6.3 \times 10^{11} \text{ ev}$; a steradian is a unit solid angle.) As measured with a thin (0.92 gm/cm^2) cesium-iodide crystal, more than 95% of this energy flux was in the less penetrating electron component. (Total energy flux is the product of individual particle energies and intensity.)

The observations of Pioneer IV show that about 30% of the radiation recorded by the unshielded counter in the lower fringe of the inner zone also penetrates the shielded counter. The radiation becomes rapidly and progressively softer (less penetrating) with distance from the earth, and in the outer zone it is almost completely absorbed by the 4 gm/cm^2 of lead shielding the Anton 213 counter.

On the basis of recent rocket studies of the lower fringe of the inner zone, by F. E. Holly and R. G. Johnson and by S. C. Freden and R. S. White, and of the extensive Explorer IV, Pioneer III, and Pioneer IV observations, the following tentative composition of the radiation trapped in the heart of the inner zone (at an altitude of about 3600 kilometers above the geomagnetic equator) is proposed by the SUI investigators: (i) electrons of energy greater than 40 kev having a maximum unidirectional intensity of about $2 \times 10^9/\text{cm}^2/\text{sec}/\text{ster}$; (ii) electrons of energy greater than 600 kev having a maximum unidirectional intensity of about $1 \times 10^7/\text{cm}^2/\text{sec}/\text{ster}$; and (iii) protons of energy greater than 40 mev having an omnidirectional intensity of about

$2 \times 10^4/\text{cm}^2/\text{sec}$. (The last two figures are probably reliable within a factor of two, the first within a factor of five.)

All evidence thus far is consistent with a composition almost exclusively of electrons for the outer zone. The energy spectrum apparently resembles that of auroral soft radiation—rising steeply toward low energies from an approximate upper limit of about 100 kev. On the basis of the simplest (though not conclusively the only) possible interpretation, in the heart of the outer zone (30,000 kilometers radial distance), the omnidirectional flux of electrons with energies greater than 40 kev is about $10^{11}/\text{cm}^2/\text{sec}$; also, the omnidirectional intensity of electrons of energy greater than 200 kev is less than $10^8/\text{cm}^2/\text{sec}$, of electrons with energies greater than 2.5 mev, less than $10^6/\text{cm}^2/\text{sec}$, and of protons of energies greater than 60 mev, not more than $10^2/\text{cm}^2/\text{sec}$.

From its behavior during the period of observation, it is inferred that the inner zone remains relatively stable with time. However, there are marked temporal fluctuations in the "slot" between the two zones, and there are fluctuations of very great magnitude, with respect to both intensity and spatial structure, in the outer zone, particularly in the "horns" where the zone approaches closest to the earth's surface.

Origin: There is little doubt that the great outer zone of geomagnetically trapped radiation, and the rich variety of associated geophysical effects, are directly attributable to solar gas injected into and temporarily trapped in the the geomagnetic field.

The site and the mechanism of acceleration of the solar gas particles to observed energies are major problems still unsettled. Two possible solutions are: (i) acceleration within the sun by betatron-type or other mechanisms and "piping" to the earth's vicinity along extended magnetic lines of force, and (ii) intrusion into the earth's magnetic field of low-energy particles

(about 10^4 ev) from a cloud of solar gas, trapping, and subsequent acceleration by magnetohydrodynamic waves or by other processes in the local earth environment. Further studies in interplanetary space, involving radiation monitoring over an extended period of time, are needed to resolve this problem.

Various workers have proposed origins other than solar, at least in part, for the radiation trapped in the Van Allen zones. H. V. Neher has suggested that a penetrating component may arise from the delayed radioactive decay of mu-mesons emerging from the earth's atmosphere as part of the cosmic-ray albedo (the secondary cosmic radiation emerging outward from the atmosphere). N. C. Christofilos, S. N. Vernov, P. J. Kellogg, and S. F. Singer, separately, have postulated the neutron component of the cosmic-ray albedo as a possible source, and Singer has emphasized the potential of such high-energy neutrons for generating the penetrating component of the inner zone. These suggestions all depend on the ability of neutrons produced by nuclear disintegrations induced by cosmic-ray bombardment of the atmosphere to move outward through the geomagnetic field, undeflected by the field or by collisions with other particles, until they undergo radioactive decay.

The observed energy spectrum and composition of the inner-zone radiation resemble those to be expected in the neutron-decay hypothesis of origin. The electrons making up the major component have an energy spectrum resembling that of neutron-decay electrons. The minor (but more penetrating) component, consisting of protons with energies of the order of 100 mev, may possibly represent part of the decay products of a few tenths of 1% of the fast neutrons making up a portion of the neutron albedo.

Many quantitative factors, such as source strength, trapped lifetimes, equilibrium spectra, etc., must be examined more fully

before the neutron-decay theory of origin of the inner zone can be established with certainty. Although present knowledge, particularly that based on the recent work of W. N. Hess, favors the neutron-decay theory, some workers feel that the source strength of the mechanism may be inadequate. T. Gold has suggested that the inner zone may contain an important admixture of particles that have been "convected" inward from the outer zone.

A number of workers have also noted the sporadic, but relatively frequent (averaging about once a month), arrival of solar protons with energies up to several hundred mev and intensities up to several orders of magnitude greater than that of the quiet cosmic-ray beam. Some investigators, including those at SUI, find it difficult to accept the trapping lifetime of several years required by the neutron-albedo hypothesis. Hence, this alternative source of protons (i.e., solar emission) of suitable energy and intensity provides another possible solution—if a valid mechanism for their admission into the inner zone can be found. Observations made during the coming period of minimum solar activity may provide illuminating evidence on temporal changes in both radiation zones.

Geophysical Role: On the basis of particle energies and intensities, geometric form of the trapped-radiation zones, estimated leakage rates into the earth's atmosphere, and general considerations of plasma physics, it appears quite plausible that the trapped radiation acts as an intermediate reservoir of charged particles between the sun, as source, and the earth's atmosphere. Resulting geophysical phenomena include the aurora, airglow, possible atmospheric heating, geomagnetic storms, etc. In addition, the trapped radiation may be the seat of the electrical current ("ring current") long supposed to be responsible for the main phase of geomagnetic storms.

Soviet reports of measurements with the USSR space probe on January 2, 1959,

indicate a gradual and progressive fall in magnetic-field strength (relative to the field extrapolated from surface measurements) between radial distances of 14,000 and 21,000 kilometers, and a subsequent rise approximately back to the theoretical value at 26,000 kilometers and beyond. These findings imply the existence of a westward-flowing ring current with an apparent maximum current density at a radial distance of about 21,000 kilometers from the earth's center. The most intense part of the ring current appears to lie along the inner side of the region of peak radiation intensity of the outer zone, where the gradient of the volume density of charged-particle kinetic energy is, in fact, at its greatest value. Further determination of the relationship between this ring current and the trapped radiation now becomes a most challenging problem for geophysicists.

It may be speculated that modification of the geomagnetic field by the ring current at a distance of about three earth radii influences the structure of the radiation zones and perhaps contributes to the existence of the slot between the two zones.

Intensity Beyond 92,000 Kilometers

The unshielded Geiger-Mueller tube in Pioneer IV provided a total of 45 hours of counting-rate observations between 92,000 and 658,300 kilometers from the center of the earth. (The shielded tube was not sufficiently sensitive to provide data during this portion of the flight.) The counting rate during observed periods (695 four-minute intervals) at no time differed with statistical significance from the over-all mean value of 1.090 ± 0.003 counts per second. The constancy of the counting rate during these periods encouraged the investigators also to "count through" the unobserved periods (during which the probe was below the effective horizons of the receiving stations) on the assumption that the counting rate for the unobserved intervals did not differ markedly from that during periods

of observation. It was found that the unobserved counting rates differed by less than 1% from the adjacent observed ones.

Solar Plasma in Interplanetary Space

On the basis of the counting-rate data, it appears that Pioneer IV did not encounter any solar plasma containing particles of sufficient energy to register on the unshielded counter during the 76-hour interplanetary portion of the Pioneer IV flight, March 3-6, 1959. This absence of energetic solar plasma is particularly notable since one theory of origin of the earth's outer radiation zone requires sporadic solar ejection of such plasma. The paucity of energetic plasma is also especially striking in view of the strong geophysical activity recorded during the previous week. The alternative theory of origin, that acceleration of the components of the plasma to high energies occurs in the geomagnetic field, is therefore implied.

Based on the characteristics of the observing equipment, it is concluded that during this 76-hour period, the time-integrated flux of higher-energy electrons and protons could not have exceeded $100/\text{cm}^2$ in an isolated burst during any one of the 695 intervals of observation; nor could it have exceeded $1000/\text{cm}^2$ in an isolated burst during any one of the three unobserved periods having a duration of some 10 hours each, or exceeded $2 \times 10^5/\text{cm}^2$ if distributed uniformly (an unlikely condition) throughout the 76-hour period. By comparison, the corresponding values for lower-energy electrons (60 kev and less) would be 4×10^5 times as great.

Interplanetary Cosmic-Ray Intensity

From the counting-rate of the Anton 302 tube in Pioneer IV, a value of $1.8 \pm 0.3/\text{cm}^2/\text{sec}$ is obtained for the interplanetary omnidirectional cosmic-ray intensity (J_0) during the period March 3-6, 1959. This value is $\frac{1}{2}$ that obtained for Decem-

ber 6-7, 1958, from Pioneer III measurements. However, on the basis of a recent re-study of the data, C. W. Snyder presents evidence that Pioneer III did not reach a great enough distance to be entirely free of the influence of the earth's magnetic field.

Since the Pioneer IV observations to very much greater distances are not subject to this uncertainty, considerably greater confidence can be attached to the new value (though it should be understood that the counter was capable of also recording low-energy protons and electrons). In any case, the Pioneer IV value provides a solid upper limit for total primary cosmic-ray intensity in the general astronomical vicinity of the earth during early March 1959.

Using balloon-borne equipment, F. B. McDonald found the following intensities of primary unidirectional cosmic-ray components (corrected to zero atmospheric depth, or to regions beyond the influence of the earth's atmosphere) at geomagnetic latitude 55° N on July 2, 1958: protons of energy greater than 280 mev, $0.0950 \pm 0.0070/\text{cm}^2/\text{sec}/\text{ster}$; alpha particles of energy greater than 158 mev/nucleon (or 632 mev/particle), 0.0149 ± 0.0012 . An interesting comparison results from multiplying the sum of these values, $0.11/\text{cm}^2/\text{sec}/\text{ster}$, by 4π to obtain an estimate of J_0 . The result is: $J_0 = 1.38/\text{cm}^2/\text{sec}$. Insofar as McDonald has been able to eliminate fast, downward-moving albedo from his data, this value has the nature of a lower limit to the total primary cosmic-ray intensity for the period of measurement. Vernov and his associates report a value of $2.3 \pm 0.1/\text{cm}^2/\text{sec}$ for J_0 on January 2, 1959.

Effective Extent of the Geomagnetic Field

The earlier interpretation of Pioneer III observations (*Bulletin No. 21*) produced the conclusion that the earth's magnetic field loses its ability to trap charged particles at a distance of about 10 earth radii.

Snyder's calculations (above) now make this value appear too small. The Pioneer IV observations, as shown in Figure 2, indicate that geomagnetic trapping is significant to a distance of about 14 earth radii, at least on specific occasions. The loss of trapping efficiency is a loosely defined concept, and marked fluctuations undoubtedly occur in the radiation regions at the outer fringes of the geomagnetic field.

Trapped Radiation Around Other Planets and the Moon

The magnetic trapping of charged particles in the vicinity of astronomical bodies is undoubtedly a quite general astrophysical phenomenon. The outward movement of cosmic-ray-produced neutrons from the atmospheres or solid surfaces of astronomical bodies is also probably a universal phenomenon—at least within our galaxy. In addition, all bodies of the solar system are subject to bombardment by solar plasma, with greater or lesser intensity de-

pending on their distances from the sun. Hence, both of the presumably most important sources of trapped radiation are present throughout our solar system.

The principal elements in a general, quantitative study of trapping are the magnetic moment and radius of the body, and the density and radial extent of its atmosphere. The trapping mechanism is now sufficiently well understood that a reasonably confident assessment can be made for any known set of these elements. In general, the greater the magnetic moment and the less extended the atmosphere, the more favorable are the conditions for a high intensity of trapped radiation.

Pioneer IV, which obtained observations as close as 61,700 kilometers to the moon, recorded no significant change in counting rate in the vicinity of the moon. It therefore appears likely that the moon is surrounded by little or no trapped radiation.

Mars and Venus, however, the planets nearest and hence of most immediate interest to us, may well be surrounded by substantial belts of trapped radiation.

International Geophysics Committee and International Geophysical Cooperation in 1960 and 1961

The following material is condensed from a more complete report, "International Geophysics Committee," by Hugh Odishaw (Director, World Data Center A, National Academy of Sciences), published in this issue of the Transactions, pages 347-350.

The International Geophysics Committee (Comité Internationale de Géophysique, or CIG) held its first and organizing session at The Hague, November 4-6, 1959. CIG

was established by the International Council of Scientific Unions (ICSU), the parent body of IGY, in conjunction with four of its member unions: the International Union of Geodesy and Geophysics (IUGG), the International Astronomical Union (IAU), the International Scientific Radio Union (URSI), and the International Union of Pure and Applied Physics (IUPAP).

The CIG's purpose is twofold: (i) to ensure the fullest possible exploitation of

the data accumulated during IGY and IGC-59 (see *Bulletin No. 28* for further information on the IGC-59 program) by maintaining the efficient functioning of the World Data Centers established as part of the IGY, encouraging discussion and use of IGY and IGC-59 results, and publishing these results and bibliographies; (ii) to develop and coordinate international plans for further cooperation in geophysics and related sciences, especially those of an interdisciplinary nature, by assembly and intercomparison of national programs, arranging for international data interchange and continued use of the WDC's, and encouraging discussion and publication of the results of such programs.

The presidents of ICSU, IUGG, IAU, URSI, and IUPAP established the membership of CIG as follows:

Bureau members: President, V. V. Belousov (USSR); three Vice Presidents, Edward Appleton (UK), John R. Winckler (USA), and M. Minnaert (Netherlands); Secretary, G. Laclavere (France).

Other members: meteorology, J. van Mieghem (Belgium); nuclear radiation, B. Bolin (Sweden); aeronomy, M. Nicolet (Belgium); geomagnetism, V. Laursen (Denmark); aurora and airglow, C. T. Elvey (USA); solar activity, M. A. Ellison (Ireland); ionosphere, W. J. G. Beynon (UK); cosmic rays, S. N. Vernov (USSR); oceanography, V. G. Kort (USSR); glaciology, G. de Q. Robin (Australia); seismology, F. Press (USA); and paleogeophysics, T. Nagata (Japan). In accordance with the CIG charter, representatives of World Data Centers A and B, Hugh Odishaw (USA) and P. K. Evseev (USSR), became members upon designation by their academies.

CIG's first meeting was concerned with the charter of the committee's functions, composition, and procedures, as drafted by the ICSU Executive Board; with completion of IGY and IGC-59 endeavors; and with international cooperation in geophysics and related sciences in the future.

Completion of IGY and IGC-59 Efforts

CIG considered completion of the IGY and IGC-59 efforts to be its first and most urgent task, and publication of the *IGY Annals* was deemed the most important aspect of this task. The CSAGI Reporters, who have in effect been serving as a board of editors for the *Annals*, each responsible for his particular discipline, were chosen to continue in this capacity in accordance with prior IGY resolutions. Their task is to compile, prepare for publication, and edit IGY-IGC results, largely embracing (i) the various types of processed data and (ii) summary reports.

In addition, the CIG urged participating IGY committees to complete IGY data interchange and to expedite IGC data flow, authorizing the Secretary to monitor this activity. The CIG also requested that the WDC's continue to prepare, issue, and distribute the cumulative six-month catalogues through December 31, 1960. The Secretary was asked to review this activity and to prepare and distribute cumulative six-month catalogues embracing all disciplines. Provisions were also made for publication of these catalogues in the *Annals*.

Plans and Recommendations

Although much analysis and interpretation of IGY and IGC observations has already been accomplished, the unprecedented extent of this body of data represents an immediate and compelling challenge to geophysics. Hence, CIG called upon adhering scientific institutions to encourage and intensify much-needed and highly valuable analytical and theoretical studies during the next two years. So significant was this activity deemed that the committee formally characterized the two-year interval, January 1, 1960–December 31, 1961, as "the IGY-IGC analysis and theoretical research period." It was stressed that research papers should be published in the customary scientific journals.

International Geophysical Calendar 1960

Issued October 1959 by the International World Day Service under the auspices of the International Council of Scientific Unions

1960 JANUARY 1960

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
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24	25	26	27	28	29	30
31						

1960 APRIL 1960

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1960 JULY 1960

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1960 OCTOBER 1960

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1961 JANUARY 1961

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1960 FEBRUARY 1960

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1960 AUGUST 1960

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1960 NOVEMBER 1960

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1960 MARCH 1960

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1960 JUNE 1960

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1960 SEPTEMBER 1960

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1960 DECEMBER 1960

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10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

12 Regular World Day

18 Regular World Day with highest priority

21 Day with unusual meteoric activity

27 Day of solar eclipse

17 18 19 20 21 Regular World Interval (RWI) combined with World Meteorological Interval (WMI)

Notes * January 11 to 20 is WMI only.

** September 18 to 22 is Provisional International Rocket Week, dates to be confirmed by COSPAR

FIG. 4. Calendar of World Days for 1960.

CIG also considered the problem of which activities, if any, merited conduct under an international aegis. The activities of IGC-59 were cited as models. These observational programs represented at most an effort only slightly greater than that which the various participating countries would have undertaken in any event. Yet, as formalized in a simple manner under IGC-59, they permitted continuity of international discourse in geophysics and, above all, sustained interchange of data through an existing mechanism. CIG therefore called for a similar effort during 1960 and 1961, to be effected by two actions of adhering scientific bodies: first, submission of program documents, which would serve to inform all participants of the nature and scope of national contributions and, second, an interchange of observational data through the WDC's.

Both IGY and IGC-59 called for extensive interchange of data, particularly in the synoptic areas—meteorology, ionospheric physics, aurora, airglow, geomagnetism, and solar activity. Although essentially complete bodies of such data were accumulated during the 1957-59 period, and their exchange was relatively thorough, it does not necessarily follow that requirements will be identical in the years ahead. Accordingly, CIG recommended periodic critical review of this matter. More specifically, the discipline members of the committee and the CSAGI Reporters were asked to examine "the needs and interests of science with respect to future interchange in consultation with relevant Union organizations and to recommend to the CIG, discipline by discipline, the exact nature and form of future [post-1959] data interchange."

Uninterrupted operation of the World Data Centers was deemed necessary, however, partly because they afford a natural, existing data-collection medium and partly because they already represent an invaluable depository for the research worker. Many decades will pass before these rich

reservoirs are exhausted, providing as they do a unique opportunity to correlate data in many fields. Special note was taken of US and USSR intentions to continue their centers and of Japanese plans to extend theirs to embrace all upper-atmosphere disciplines.

In addition to providing a basis for international continuity in "normal" geophysical studies, as suggested above, CIG considered special endeavors that might be undertaken. In this connection, special notice was taken of the World Magnetic Survey planned for a quiet interval in the solar cycle. This survey was initially proposed early in the IGY by Professor Sydney Chapman, and has recently been under intensive study, particularly by the IUGG International Association of Geomagnetism and Astronomy. CIG not only endorsed the Survey but suggested that "adjoint programmes in the fields of upper atmosphere research should be considered" for this same period, a few years hence. CIG concluded its consideration of the broad subject of future special efforts with an invitation for assistance from its discipline members, the sponsoring unions, and adhering academies.

The proposed two-year observational period of 1960-61, the ensuing pattern of data interchange, the World Magnetic Survey and, possibly, related studies during sunspot minimum, and proposals for additional major researches in years ahead will all be discussed at one time or another during the next year or two. The General Assemblies of IUGG and URSI, and associated international symposia, afford splendid opportunities for colloquies among specialists. However, some of these topics require prompt consideration, since planning and organizing of even the simplest type, whether nationally or internationally, take time. Hence, CIG will meet again in late March or early April of 1960, and a meeting of the World Data Centers and of the Permanent Services is tentatively scheduled for May 1960. National programs for

1960-61 may well be called for and arrangements for data interchange outlined.

Organization of Programs

Just as IGY's scientific strength rested heavily upon the CSAGI Reporters, the programmatic responsibilities of CIG fall largely upon the discipline members. It is expected that the Unions will provide support through their specialized groups, thus broadening the base of the discipline members' suggestions and recommendations. Close relationships between CIG and special committees are also necessary. In particular, provisions are included for appropriate liaison with the following three ICSU committees: COSPAR, which has cognizance over rocket and space science; SCAR, which is responsible for Antarctic activities; and SCOR, which is concerned with all aspects of oceanic and marine sciences. Similar ties exist with the International World

Days Service, which will continue the World Days program that proved so valuable during IGY and IGC-59. (See Figure 4.)

National participation in CIG activities is recognized as a responsibility of the scientific organizations adhering to ICSU. In the United States, the National Academy of Sciences must accordingly determine the appropriate mechanism for its cooperation with CIG. Discussions during the last year suggest that the variety of interests in the United States calls for an approach that combines the interests and competences of the four US National Committees serving as domestic counterparts to IUGG, IAU, URSI, and IUPAP, together perhaps with representation of several specialized Academy committees. The Executive Committee of the American Geophysical Union, at its meeting on November 14, 1959, endorsed in principle an approach of the above kind and indicated its intent to participate vigorously in the actions of such a body.

Ice Thickness and Bottom Topography of the Filchner Ice Shelf and Along the Ellsworth-Byrd Traverse Route

The following material is based on reports by Edward Thiel and J. C. Behrendt, members of the 1957-58 oversnow traverse from IGY Ellsworth Station, and by Father E. A. Bradley, SJ, and F. T. Turcotte, members of the Ellsworth-Byrd traverse, 1958-59.

The oversnow traverse from IGY Ellsworth Station during the Antarctic summer of 1957-58 was confined for the most part to the Filchner Ice Shelf and its fringes. It provided much new information regarding the areal extent of the shelf, its thickness, and the configuration of the un-

derlying bedrock surface, supplementing information gained on exploratory flights over the western portion of the ice shelf and the eastern part of the Ellsworth Highland made during the Ronne Antarctic Research Expedition of 1947-48.

The 67-day, 1250-mile Ellsworth-Byrd Station traverse in the 1958-59 summer season, also carried out by scientific and support personnel from Ellsworth Station, resulted in further knowledge of the ice shelf as well as of ice thickness and sub-ice topography between the edge of the shelf and IGY Byrd Station. Both traverse parties used seismic, gravity, and magnetic techniques

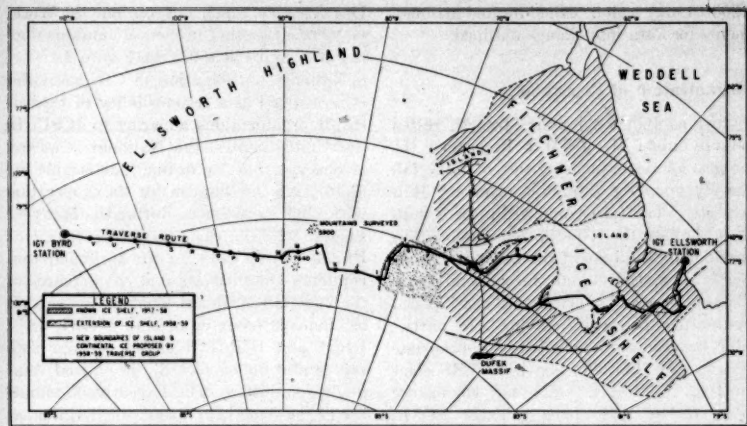


FIG. 5. US-IGY Traverse Routes from Ellsworth Station. Dotted line represents Filchner Ice Shelf traverse, 1957-58; solid line represents Ellsworth-Byrd traverse, 1958-59. Large, lettered dots are seismic stations along the latter route; dash-dot line is approximate axis of trough beneath the ice shelf.

primarily for these studies. This report summarizes their findings.

Filchner Ice Shelf

The 1957-58 Ellsworth traverse made three major discoveries concerning the physical geography of the Filchner Ice Shelf: (i) the shelf extends much farther inland and, therefore, has a much greater area than previously supposed; (ii) the

shelf is grounded on at least two "islands," one of them of considerable area, and (iii) a deep trough extends inland beneath the shelf from the barrier edge east of Ellsworth Station. (See Figure 5.)

Prior to the IGY, the inner edge of the Filchner Ice Shelf was thought to be about 50-70 miles from the sea in most places, with a maximum of about 150 miles along the western border. The investigations of the 1957-58 Ellsworth Station traverse

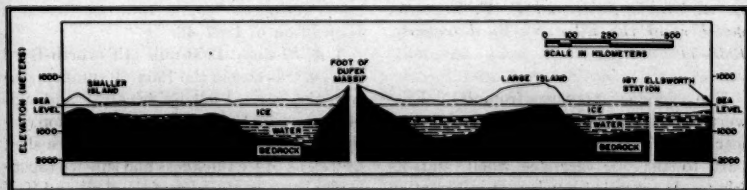


FIG. 6. Profiles Across Filchner Ice Shelf Along 1957-58 Ellsworth Traverse Route. (Compare with Figure 1.)

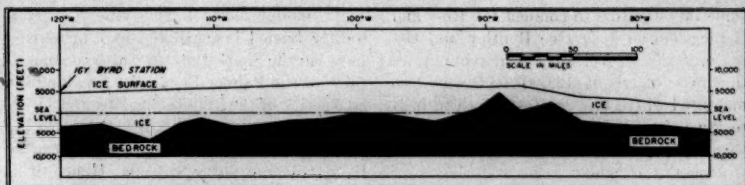


FIG. 7. Profile from Inland Edge of Filchner Ice Shelf to IGY Byrd Station. (Compare with Figure 1.)

party, however, showed that the shelf extends inland for distances greater than about 300 miles in most places. In addition, the Ellsworth-Byrd traverse group established the actual contact between the shelf and the mainland along the traverse route an additional 100 miles farther inland. Thus, although its boundaries are still not delineated with certainty in all places, the areal extent of the Filchner Ice Shelf, estimated at approximately 160,000 square miles, is now seen to be comparable to that of the great Ross Ice Shelf (about 210,000 square miles) on the opposite side of Antarctica.

Figure 6, based on seismic investigations conducted along the 1957-58 traverse route, contains profiles of the Filchner Ice Shelf and the islands. Although below sea level almost everywhere they were crossed, these areas are termed islands because they are considerably higher than the surrounding shelf-ice areas and because the overlying ice is actually grounded instead of afloat. In its 1958-59 traverse across the ice shelf, the Ellsworth-Byrd party crossed the large island mapped by the traverse group of the previous year and was able to fill in some additional details of the shelf and the island, as shown in Figure 5.

Figure 5 also indicates the approximate position of the axis of a 3500-foot-deep trough beneath the Filchner Ice Shelf between the large island and the mainland area to the east and southeast of the shelf. It was previously theorized that this trough might represent the Weddell Sea side of a

great trans-Antarctic trough thought to extend from the Ross to the Weddell Sea. Whether such a trough actually exists across all of the region between the two seas, however, is still a matter of debate. (See discussions in *Bulletins 19* and *25*, and below.)

Region Between Filchner Ice Shelf and Byrd Station

In the region just beyond the inland edge of the Filchner Ice Shelf, the Ellsworth-Byrd traverse party found a rise in the bedrock surface from about 4000 feet below sea level near the edge of the shelf to about 4000 feet above sea level in a mountainous region in the vicinity of 88°W (see Fig. 7). The mountain area extends at least 70 miles in an east-west direction and appears to be above sea level throughout this region. A number of prominent peaks projecting well above the snow surface were surveyed; the tallest reaches a height of about 7650 feet above sea level, while the surrounding ice-surface elevation ranges from about 4500 to 7000 feet. The group containing this peak was visited and found to be composed of dark gneiss in sharp contact with a light-tan biotite granite.

The region between these mountains and Byrd Station has a bedrock surface virtually everywhere well below sea level. A maximum depth of approximately 6300 feet was measured at 80°35'S, 114°57'W, about 70 miles east of Byrd Station in the region of a broad trough believed by

some investigators to connect the Ross and Bellingshausen Seas (see Bentley and Ostenso, *Bulletin No. 25*). A maximum ice thickness of about 12,000 feet was also measured where this greatest depth to bed-rock was found. The topography of the sub-ice surface in this part of the traverse route is generally irregular.

Trans-Antarctic Trough

It was originally hoped that seismic investigations carried out on the Ellsworth-Byrd traverse would furnish evidence either confirming or denying the existence of a trough between the Ross and Weddell Seas. The 70-mile-wide mountainous area in the vicinity of 88°S lends further support to the suggestions of Edward Thiel, N. A. Ostenso, and C. R. Bentley (*Bulletin No. 25*) that a

high, mountainous land connection (but mostly buried beneath the ice) may exist between the South Pole area and the mountains of the Palmer Peninsula, breaking the continuity of the hypothetical trough. However, it is not yet known how far south the mountain zone found by the Ellsworth-Byrd traverse party extends. Hence, it is still possible that the trough lies to the south of the traverse route.

An airborne traverse along the 88°W meridian between the Sentinel and Horlick Mountains, to be led by Thiel, is planned for the 1959-60 Antarctic summer season. Seismic, gravity, and magnetic investigations made on this traverse should throw further light on the southward extension of the mountain region discussed above and, therefore, on whether the hypothetical trans-Antarctic trough actually exists.

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